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27th YEAR

THE MINERAL INDUSTRY

1892–1918

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THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1918

FOUNDED BY RICHARD P. ROTHWELL

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VOLUME XXVII

SUPPLEMENTING VOLUMES I TO XXVI

McGRAW-HILL BOOK COMPANY, INC.
239 WEST 39TH STREET. NEW YORK

LONDON: HILL PUBLISHING CO., LTD.
6 & 8 BOUVERIE ST., E. C.

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State.	Name and Address.	State.	Name and Address.
ALABAMA	Eugene A. Smith, State Geologist, University.	NEW YORK	John M. Clarke, State Geologist, Albany.
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COLORADO	R. D. George, Director, Boulder.	N. DAKOTA	A. G. Leonard, State Geologist, Grand Forks.
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ILLINOIS	F. W. DeWolf, Director State Geological Survey, Urbana.	PENNSYLVANIA	R. R. Hice, State Geologist, Beaver.
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ARKANSAS	John H. Page, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock; John T. Fuller, State Mineralogist; Claud Speegle, State Mine Inspector, Fort Smith.
CALIFORNIA	H. M. Wolflin, Chief Mine Inspector, San Francisco; F. McN. Hamilton, State Mineralogist, San Francisco.
COLORADO	Fred Carroll, Commissioner, Bureau of Mines, Denver; James Dalrymple, Chief Inspector of Coal Mines, Denver.
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VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1919

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins and Remarks.
Argentine Republic.	Gold...	Peso.....	$0.9648	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. Currency: Depreciated paper, convertible at 44 per cent. of face value.
Austria-Hungary..	Gold...	Krone.....	.2026	Gold: 10 and 20 crowns. Silver, 1 and 5 crowns. Greatly depreciated; no quotations.
Belgium.....	Gold...	Franc.....	.1930	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia.....	Gold...	Boliviano.....	.3893	Silver boliviano and divisions, 12½ bolivianos equal 1 pound sterling.
Brasil.....	Gold...	Milreis.....	.5462	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. Currency: Government paper. Exchange rate about 27 cts. to the milreis.
British Colonies in Australasia and Africa.	Gold...	Pound sterling.....	4.8665	
Canada.....	Gold...	Dollar.....	1.0000	
Central America. Costa Rica.	Gold...	Colon.....	.4653	Gold: 2, 5, 10 and 20 colons ($9.307) Silver: 5, 10, 25 and 50 centimos.
British Honduras.	Gold...	Dollar.....	1.0000	
Nicaragua.....	Gold...	Cordoba.....	1.0000	
Guatemala... Honduras.... Salvador.....	Silver .	Peso.....	.7234	Silver: peso and divisions. Guatemala: Currency, inconvertible paper, exchange rate about $0.40. Honduras: Currency, bank notes. Salvador: Currency, convertible into silver on demand.
Chile.....	Gold...	Peso.....	.3650	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.2825.
China..	Silver	Tael.. Amoy.....	1.1859	The tael is a unit of weight; not a coin. The customs unit is the Haikwan tael. The values of other taels are based on their relation to the value of the Haikwan tael. The Yuan silver dollar of 100 cents is the monetary unit of the Chinese Republic; it is equivalent to .644 + of the Haikwan tael.
		Canton.....	1.1823	
		Cheefoo.....	1.1342	
		Chin Kiang..	1.1585	
		Fuchau.....	1.0970	
		Haikwan (customs)	1.2066	
		Hankow.....	1.1096	
		Kiaochow....	1.1492	
		Nankin.....	1.1735	
		Niuchwang..	1.1121	
		Ningpo.....	1.1402	
		Peking.....	1.1561	
		Shanghai....	1.0832	
		Swatow.....	1.0955	
		Takau.....	1.1934	
		Tientsin.....	1.1492	
		Dollar Yuan.....	.7771	
		Dollar Hongkong...	.7800	
		Dollar British.....	.7800	
		Mexican.....	.7857	
Colombia.....	Gold...	Dollar.....	.9733	Gold: condor ($9.647) and double condor. Silver: peso.
Cuba.....	Gold...	Peso.....	1.0000	Currency, Government paper and gold; exchange rate, approximately, $1.02 to 1 gold peso.
Denmark.....	Gold...	Krone.....	.2680	Gold; 10 and 20 crowns. Exchange rate, $0.312 = 1 krone.
Ecuador.....	Gold...	Sucre.....	.4867	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1918.

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INTRODUCTION

For each of the past four years there has been a steadily increasing difficulty imposed on the preparation of a review of the kind that MINERAL INDUSTRY is intended to be. The desire is to cover the field in as broad a way as the space at our command will permit and to make the treatment as nearly international in character as the information at hand enables us. This ideal is, at best, one which is not easy to accomplish, and with such conditions as have prevailed throughout the civilized world for the past four years, it vanishes into the realm of the impossible.

Now, however, conditions are beginning to improve, and it is hoped that, as the warring nations again take up their peaceful pursuits, the amount of information available concerning present operations, and also those of the past few years, will materially increase. This return to more normal conditions has already been heralded by the receipt of the first copy of the *Annales des Mines de Belgique* to appear since the German invasion of that country. And with this comes the full report of the mineral and metal production of the occupied territory for the full period of the war, and a résumé of the conditions of the leading industries as abandoned by the Germans. And the fact that such a striking series of data were made public inside of three months from the time the German army evacuated Brussels should certainly serve as an inspiration to the more favored of the belligerent nations.

It is a matter of considerable importance that information in regard to the progress of the war years should be disseminated as fully and as promptly as possible, for it is impossible for an industry as a whole to settle down to its normal stride until the various component factors of the industry have a reasonable amount of knowledge concerning the present status of the industry as a whole. It is in this field of labor that the object of MINERAL INDUSTRY lies—namely, to assist in the collection and dissemination of this very necessary information.

Volume 27 holds to the scope and purposes outlined for its predecessors. The mineral industries are discussed in individual chapters, alphabetically arranged, covering, to the fullest extent permitted by the information in hand and the space available, the status of the industry both in the United States and in foreign countries. The preparation of the various chapters has, wherever possible, been placed in the hands of someone of recognized standing in the industry, in order that the

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importance and accuracy of the material incorporated in the chapter may be given proper consideration.

But, while the desire is to make the scope of the volume as broad as possible, it must be borne in mind that under present conditions full information is decidedly lacking, and the more remote the source, the scarcer it is. This fact, coupled with necessity of having practically all of our contributors in the United States, where they can be promptly reached, leads to the inevitable result that much of the material is treated primarily from the American standpoint.

In general, it is aimed to take up in each chapter the general progress during the calendar year in the industry concerned, both from a statistical and a technical standpoint, in such a manner as to supplement and continue the corresponding chapters in previous volumes.

The material utilized is from four general sources: the official reports of the geological and mining bureaus of the various governments; the publications of the United States Geological Survey, supplemented by the corresponding State organizations; the columns of the current technical press; and the personal knowledge and correspondence of the individual contributors.

We owe special acknowledgment to the columns of the following periodicals: *Engineering and Mining Journal, Mining and Scientific Press, Bulletin of the American Institute of Mining Engineers, Chemical and Metallurgical Engineering, Coal Age, Iron Age, Salt Lake Mining Review, Mining Journal, Mining Magazine, Canadian Mining Journal, Canadian Chemical Journal, Queensland Government Mining Journal,* and *South African Mining and Engineering Journal;* also to the various publications of the U. S. Geological Survey, the U. S. Bureau of Mines, and the U. S. Bureau of Foreign and Domestic Commerce.

Sincere thanks are also due to all of the contributors, for to their efforts is directly traceable most of the credit for such value as this volume may have.

And in conclusion, a word as to the physical make-up of the volume. A number of minerals of less importance, at least from a technical standpoint, have not been covered in this work. This applies in particular to those connected with the pottery and building trades, whose raw materials are so widely distributed that a general report would require space out of all proportion to its value in a review of this kind. On the other hand, some industries relating to manufactured material are included, when the product is directly dependent on the production of raw minerals, or where it is being substituted for them, as in the case of cement, coke, and sulphuric acid.

In order that the volume may appear within a reasonable time

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after the close of the year, and still contain a maximum of useful information, it is necessary in many cases to use preliminary figures and estimates, which are then corrected in later issues. Hence, it is important in using MINERAL INDUSTRY always to use the latest volume, even for figures for previous years, in order to get the benefit of these corrections.

G. A. ROUSH.
ALLISON BUTTS.

BETHLEHEM, PA.
July 15, 1919.

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ABRASIVES

By J. Volney Lewis

Expansion and an upward tendency in prices continued to characterize the abrasive situation in the United States throughout 1918. This was particularly marked in the manufacture of artificial abrasives. There was a decrease in the production of natural abrasives. A small amount of corundum continued to come from North Carolina, but the Peekskill, N. Y., emery district fell considerably below its record production of some 16,000 tons for 1917. The decline here was only partly compensated by the development of the new emery field in Virginia. According to statistics compiled by F. J. Katz, of the United States Geological Survey, the quantity of corundum and emery mined was 10,139 short tons. The quantity of crude emery and corundum marketed was 10,922 short tons, valued f o.b. mines at $112,878. The output was 32 per cent. less than that in 1916 and 39 per cent. less than that in 1917.

With Grecian emery selling at 2½ to 3 times its normal pre-war prices there was good demand for domestic abrasives, both corundum and emery, which can be produced at a considerably lower cost; but with the return of the imported materials a falling off in domestic production is to be expected, since it cannot compete in either price or quality under any approach to the old conditions.

A feature of the war situation that was important far out of proportion to the quantities of material involved was the problem of a suitable abrasive for the exacting demands of optical glass work. This was second in importance only to the production of optical glass itself, and the vastly increased demand for instruments for use in the war had seriously depleted the reserve supply of abrasives suitable for this purpose before a satisfactory solution was found. After extensive tests of all available types of natural and artificial materials only small amounts could be found to eke out the supply. A supply of India corundum was eventually obtained through the War Trade Board, when it was found that a special mill would have to be built for its reduction and treatment. This was necessary because all the emery mills of the country were then engaged in grinding artificial abrasives, and it was deemed essential that the smallest traces of such material should be excluded from abrasives for fine optical grinding. Hence the American Abrasive Co. was formed with the special object of supplying the optical industry, and a mill for this purpose was erected during the year at Westfield, Mass.

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For fine optical work the crushed corundum or emery must be mulled for several hours before grading. This accomplishes the double purpose of removing any attached feldspar, mica, or other impurities and at the same time reducing the sharp points and edges of the abrasive itself, producing a more rounded grain and removing the danger of making deep cuts and scratches in the glass.

Producers of artificial abrasives had previously made some study of the requirements of the optical industry, and this was resumed at the request of the War Trade Board. Eventually they succeeded in producing a satisfactory artificial material which would have been used if the natural abrasive had not been obtained, although the cost would be prohibitive except in an emergency.

Vigorous production of emery was kept up throughout the year and the market demands were supplied at prices 2 to 3 times the prewar prices, although the domestic product was hardly a satisfactory substitute for Grecian and Turkish emery in all its uses.

The importance of abrasives in industrial development has been recognized by the British Ministry of Reconstruction through the appointment of an Abrasives and Polishing Powders Research Committee for the purpose of investigating (1) the preparation and use of abrasives for optical purposes, and (2) the properties and preparation of abrasives in general.

The United States Shipping Board and the War Trade Board restricted the importation of emery and corundum for the year 1918 to 4000 long tons of Greek emery and 750 long tons of corundum from India and South Africa. A new ruling in October authorized the further importation of 450 tons of finished grains of corundum from England, to be allocated by the Bureau of Imports.

EMERY

The emery trade in 1918 showed a continuance of the conditions that marked the preceding two years: unusual demand on the part of the metal and glass industries and curtailment of imports which hitherto have held a prominent place in the market. As a consequence the domestic producers experienced an active and prosperous season, and the mines in the Peekskill district of New York and the newly opened Virginia district made good the deficiency of imports, at least so far as quantity was concerned, although the quality for some uses was not all that could be desired.

New York. (By D. H. Newland.)—The Peekskill district of Westchester County includes a number of small mines and has been for many years the leading producer of emery in this country. The industry,

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however, did not attain much importance until within the last 4 years, during which time it has contributed about 50,000 tons of lump ore or rock, which is more than the total output in the preceding two decades.

The product all goes outside of the district for grinding and manufacture, as there are no mills for the purpose in the vicinity. In ordinary times it is not an active competitor of the foreign emery, but constitutes a limited substitute for it in certain abrasive uses. Practically the entire output is used in the form of grains, little or none of it being made into wheels, since it does not stand up well under the heat necessary for the vitrified bond.

The deposits are distributed irregularly over the area of igneous rocks that lies just south and east of Peekskill. There are probably several hundred openings altogether, ranging from mere prospect trenches to pits that measure 200 or 300 ft. long and 30 to 40 ft. wide, with a depth seldom in excess of 50 feet. There is also a great variation in the shape of the deposits. Some are mere wisps or splashes of ore in the country gabbro, without any definite trend or form; others show more or less resemblance to a lens, usually elongated in one direction; and still others may be described as stringers or pockets. Very little dependence can be placed upon their continuity beyond the limits of the explored ground.

The work of mining is carried on with a minimum of mechanical equipment. The emery is broken out largely by hand, since power drills are not found efficient in such hard material. The lumps are sorted according to quality and put in piles for hauling to the railroad. The best grade, or No. 1 emery, is a heavy, fine-grained bluish-black ore, sometimes with a pink tinge, in which the mineral components are scarcely distinguishable except with the microscope. This ore contains mostly corundum and magnetite, but carries some green spinel, a little garnet, quartz, and other minerals. Another type that is rather common is gray ore, in which there are plentiful lath-shaped inclusions of sillimanite, very apparent in the hand specimen, inclosed within a fine groundmass of magnetite, spinel, allanite, and corundum.

The price obtained for lump ore during the past year has averaged $8.00 a ton f.o.b. Peekskill, the principal shipping point. The most important openings, including those on the McCoy, Dalton, Lancaster, Rand, Sprang, and Buckbee farms, are within an area of about a square mile east and southeast of Peekskill. The principal shippers during the past two or three years have been the Keystone Emery Mills, Blue Corundum Mining Co., Tanite Co., J. R. Lancaster, Smith & Ellis, and John Smith, Jr.

A possible new use for Peekskill emery is indicated by experiments that have been carried out recently in making pebbles and linings for

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tube mills used in grinding minerals and ores. The extreme toughness of the rock suggested its possible adaptability to the purpose, and tests of a preliminary character have tended to confirm the expectation of its wearing qualities, showing it to be superior in this respect to most kinds of silica pebbles. The relative merits and costs have not been determined on a large-scale practical basis, and until that is done judgment must be withheld.

Virginia.—The newly discovered spinel emery deposits of Pittsylvania County, Va.,[1] are being actively developed by two companies, one of which was also active in the latter half of 1918, and considerable shipments have been made. The material is used chiefly in powdered form for polishing purposes, and is said to have given satisfactory results. The mines are near Whittles, the present shipping point, on the Southern Railway, about 20 miles north of Danville and 40 miles south of Lynchburg.

The emery area comprises about 20 sq. mi. in the crystalline rock complex of the Piedmont Plateau. The rocks are chiefly mica schist, which is deeply weathered, and outcrops are few. There are also some gneisses, and both rocks are in part garnetiferous. The strike is variable northeast and the dip from vertical to 40° southeast. Igneous rocks include several kinds of granite, norite, and diabase, and pegmatites and quartz veins are numerous. The emery is in or closely associated with a granite-aplite-pegmatite, with which it is thought to be genetically connected. It forms sharply defined vein-like masses or lenses up to 6 ft. thick, chiefly lying in the foliation planes of the country rock, and the greatest length thus far exposed is 120 feet. The ore is more resistant than the inclosing rocks and the surface is littered with large and small masses of it. The schists are decomposed to residual clays, red or brown in color, which preserve the structure of the original rock. Alongside of the emery there is generally much chlorite, up to several inches thick, and some of it is interlaminated, or in bunches in the ore near the contacts. In some leaner ores chlorite is abundant throughout the mass, but it is characteristically absent from the richer bodies. Sillimanite and andalusite are also present in places.

The rock emery is a heavy black fine-grained crystalline aggregate, resembling magnetite. It is magnetic from the presence of magnetite, and is exceedingly tough. Most of it is uniform in texture, but banded finer- and coarser-grained varieties are common. In the dominant type of dense ore the grains are less than 0.1 mm. in diameter, and hence are indistinguishable to the unaided eye, and in the coarsest varieties the grains do not exceed 2 mm. The orebodies in the schists (but not those in the granites) contain recognizable colorless and blue corundum in

[1] Thos. L. Watson and George Steiger, *Wash. Acad. Sci.*, Vol. 8, No. 21, Dec. 19, 1918.

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bunches and streaks. Crystals are also found from 1 to 3 mm. long and 1 mm. thick, and exceptionally 25 by 10 mm.

The microscope shows a fine-grained interlocking aggregate of spinel (pleonaste), magnetite, and corundum, with some ilmenite. Spinel constitutes 50 per cent. or more of the rock. Magnetite, the next in importance, is much less abundant than spinel. Corundum is abundant in some sections and almost or entirely wanting in others.

Uruguay.—Emery has been found in the San Francisco valley in Minas, in an isolated conical hill 60 m. high and 250 m. in diameter, and in a smaller outcrop nearby. It grades into the inclosing schists and is supposedly the result of pneumatolytic processes accompanying the intrusion of a large granite mass west of the deposits. The emery is fine-grained and contains only a small amount of magnetite and no pyrite or other injurious minerals.[1]

Corundum

North Carolina.—The mine at Corundum Hill, Macon County, was worked to only a small extent during 1918. The property has now changed hands and it is said that a Boston company is to be organized to operate it in connection with several others, with the expectation of increasing the output. The mining is said to be profitable at the present high prices, although any considerable reduction in the prices of artificial abrasives would doubtless stop the output altogether.

A newly discovered deposit of so-called emery is reported from the vicinity of Franklin, Macon County. It is said to carry about 50 per cent. corundum in grains and crystals from the size of a pea to the size of buckwheat. About 500 tons of it have been shipped, and it is reported to have been used successfully in wheels for iron and steel work, especially if mixed with about one-fourth its weight of artificial corundum. The quantity available is thought to be large, but the exact nature and extent of the deposit await determination.

Ontario.—The Manufacturers Corundum Co., Ltd., operated the mine at Jewelville in 1918, and milling operations, which had been suspended in the preceding July, were resumed in January. The ore can be hauled to the mill only over the winter roads. The output of corundum grains in 1918, as reported to the Canadian Department of Mines, was 137 tons, valued at $26,112, a decrease of 51 tons from the production of 1917. The average value, however, was $190.60 per ton, as against $171.03 in 1917. Most of the product, as in former years, was shipped to the United States.

South Africa.—Corundum has been known for many years in the schists

[1] "Mineral Deposits of South America," B. L. Miller and J. T. Singewald, Jr., New York, 1919, p. 522.

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of the Zoutpansberg and Barberton areas of the Transvaal, but it was not considered of any importance until the war demand brought it into prominence. An export trade from the former district is said to have reached a figure of about 200 tons per month and seemed capable of great expansion. The output in 1916 was 755 tons, valued at £7762.

The corundum occurs in broken crystals in the surface detritus of the gneisses and is recovered by screening and washing in rotary pans. The gravel ranges up to 2 ft. thick, and along some belts it contains 5 to 10 per cent. of corundum. It is mined at many places in an area about 30 miles in diameter, but the limits of its occurrence have not been determined. The parent rock, containing the corundum, consists in places almost entirely of feldspar, in others of quartz, and in still others it is mica schist—all forming bands in the gneiss. Besides loose crystals, boulders of the rock containing up to 60 per cent. corundum are found, some of them too large to be handled by present methods. The work is done mostly by native women and children at a cost of only a few shillings a ton.

A small output was obtained from a similar occurrence of corundum in sillimanite gneiss at Steinkopf in Namaqualand. Corundum-bearing rocks are also known in the Bubi, Selukwe, Charter, and Makoni districts of Rhodesia.[1]

Grinding Pebbles and Tube Liners

The output of "artificial pebbles" from quartzite at Sioux City, Iowa, and from silicified rhyolite at Manhattan, Nev., was considerably greater in 1918 than in 1917, according to statistics gathered by the United States Geological Survey; but there was considerable falling off in the production of natural pebbles from the beaches of San Diego County, Calif., and the net result was a decrease of 20 per cent. in the output of pebbles, although there was an increase of 30 per cent. in value. The decrease is attributable in part to the increasing use of lumps of ore and mine rock and of steel balls as substitutes for pebbles. It is estimated that a little over 10,000 tons of flint pebbles were imported, about 70 per cent. of which came from Denmark. The novaculite pebbles of Arkansas have not yet been used.

Tube-mill lining was produced from the flint beds of Iron City, Tenn., and from the quartzite at Sioux City, Iowa. The total output in 1918 was 2535 tons, valued at $46,634, compared with 3050 tons valued at $59,250 in 1917.

Grindstones and Pulpstones

According to the figures compiled by the United States Geological Survey, the total sales of these stones in 1918 amounted to 65,399 short

[1] *So. Afr. Min. Jour.*, June 29 and Aug. 10, 1918.

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tons, valued at $1,776,282, a gain of 10,967 short tons, or 20 per cent., in quantity and of $455,706, or 55 per cent., in value. The average price per short ton was $28 in 1918, an increase of $13 over the average in 1917. Labor shortage was the chief obstacle encountered by the quarrymen in 1918. The demand was good. Over 85 per cent. of the material used in the manufacture of grindstones was sandstone quarried in Ohio, and the remainder was sandstone quarried in Michigan and West Virginia.

The pulpstones sold in 1918 from sandstone quarried in Ohio and West Virginia amounted to 8785 tons—2921 pieces—valued at $513,680, an increase of nearly 26 per cent. in quantity and of 50 per cent. in value. Owing to the shortage of labor the supply did not exceed the demand, and very little stock was left over for 1919.

Oilstones and Scythestones

Fewer oilstones and scythestones were made in 1918 than in 1917, but the value of the output increased, according to reports of producers to the United States Geological Survey.

The sales of oilstones, including whetstones, in 1918 amounted to 559 short tons, valued at $134,376, a decrease of 666 short tons (54 per cent.) in quantity, but an increase of $17,466 (15 per cent.) in value. These stones were manufactured from stone quarried in Arkansas, Indiana, and Ohio.

The sales of scythestones in 1918 amounted to 6011 gross (about 330 short tons), valued at $37,125. This was a decrease of 1198 gross (16 per cent.) in quantity and an increase of $5380 (17 per cent.) in value. These stones were made from material quarried in Michigan, New Hampshire, Ohio, and Vermont.

The hones and rubbing stones manufactured and sold in 1918 amounted to 121 tons, valued at $17,532, a decrease of 36 per cent. in quantity and of about 13 per cent. in value.

Artificial Abrasives

In 1917 the output of artificial abrasives nearly trebled the value of the preceding year, although there was less than 50 per cent. increase in quantity. An even greater increase was made in the first half of 1918, amounting to nearly 60 per cent., as reported to the United States Geological Survey. More than 80 per cent. of the total was aluminium oxide abrasive, or artificial corundum, made from domestic bauxite, although a considerable part of it is manufactured in Canada. It is marketed under a variety of trade names, such as alundum, aloxite, exolon, lionite, natite, and coralox, and 19 per cent. of the bauxite mined was consumed in this industry. Next in importance was silicon carbide,

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sold as carborundum, crystolon, and carbolon. Crushed iron and steel abrasives formed about 2 per cent. of the total.

ACKNOWLEDGMENTS

The writer is indebted to miners, manufacturers, and dealers for kindly assistance and coöperation. Special acknowledgments are due to Dr. Thomas L. Watson, State Geologist of Virginia; Mr. D. H. Newland, Assistant State Geologist of New York; Mr. E. A. Scheibe, Purchasing Agent of Bausch & Lomb Optical Co.; and Mr. W. P. Leshure, President of Hampden Corundum Wheel Co.

STATISTICS

HIGH-GRADE ABRASIVES IN THE UNITED STATES, 1912–1918
(In short tons)

	Domestic.		Imported Emery and Corundum.	Total Mineral Abrasive.		Artificial Abrasives.			
						Domestic.		Imported Value.	Total Value.
	Garnet.	Emery and Corundum.		Tons.	Value.	Tons.	Value.		
1912	4,947	992	19,425	25,364	644,743	15,501	1,747,120	88,550	1,835,670
1913	5,308	957	20,425	26,690	645,802	16,744	2,017,458	190,290	2,207,748
1914	4,231	485	14,457	18,968	508,800	15,830	1,685,410	233,799	1,919,209
1915	4,301	3,895	10,116	17,480	435,732	18,842	2,248,778	255,474	2,504,252
1916	6,171	15,282	9,252	30,705	533,976	38,806	2,935,909	940,219	3,876,128
1917	4,995	17,135	2,250	24,380	649 979	57,911	8,137,242	1,758,910	9,896,152
1918	4,696	10,422	9,548	24,666	975,206	.....	.....	1,962,280	.....

EMERY PRODUCED IN THE UNITED STATES, 1912–1918
(U. S. Geological Survey)

Year.	Short Tons.	Value.	Average per Ton.
1912	992	$6,652	$6.71
1913	957(a)	4,785(a)	5.00(a)
1914	485(a)	2,425(a)	5.00(a)
1915	3,063(a)	31,131	10.17(a)
1916	15,282	123,901	8.11
1917	17,135(b)	241,050(b)	14.07(b)
1918	10,422(c)	112,878(d)	10.83(d)

(a) Estimated. (b) Includes 820 short tons of corundum from North Carolina, valued at $67,461, or $82.28 per ton; the emery alone averaged $10.64 per ton. (c) Includes North Carolina corundum. (d) Value of marketed material.

PRODUCTION OF CORUNDUM IN CANADA, 1912–1918
(Canadian Department of Mines)

	Tons.	Value.	Average per Ton.
1912	1,960	$233,212	119.00
1913	1,177	137,036	116.42
1914	548	65,730	119.96
1915	262	33,138	126.48
1916	67	10,307	153.84
1917	188	32,153	171.03
1918	137	26,112	190.60

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IMPORTS OF EMERY INTO THE UNITED STATES, 1913–1918
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Manufactures Value.	Total Value.
	Long Tons.	Value.	Pounds.	Value.		
1913	18,964	$328,211	922,660	$37,307	$15,067	$380,585
1914	14,197	275,973	844,157	33,874	20,874	330,721
1915	7,194	152,088	629,581	25,011	.....	177,099
1916	10,255	194,954	461,461	18,712	35,142	248,808
1917	2,000	14,282	136,969	7,889	33,535	55,706
1918	3,609	88,875	482,289	32,371	44,390	121,246

Grecian emery ore, heretofore largely imported direct, came chiefly through France in 1918, with smaller amounts from England and Spain. The grains were mainly from England and Canada, with smaller amounts from Greece and Spain. Manufactures were chiefly from England, with minor shipments from France and Switzerland.

IMPORTS OF CORUNDUM INTO THE UNITED STATES, 1913–1918
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Total Value.
	Long Tons.	Value.	Pounds.	Value.	
1913	541	$78,401	1,937,803	$87,187	$165,588
1914	294	39,772	1,114,051	61,026	100,798
1915	183	23,701	831,350	39,914	63,615
1916	17	633	657,826	29,471	30,104
1917	283	27,503	2,310,594	128,941	156,444
1918	1,182	119,522	3,421,454	189,345	308,867

Imports and prices of corundum continued strong through the early months of 1919.

SOURCES OF CORUNDUM IMPORTS, 1913–1918
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore and Rock (Long Tons).					Grains (Pounds).			
	Canada.	United Kingdom.	S. Africa.	Other.	Total.	Canada.	United Kingdom.	Other.	Total.
1913	421	114	.....	6	541	1,872,500	64,300	1,003	1,937,803
1914	168	113	.....	13	294	659,200	423,427	31,424	1,114,051
1915	149	33	.....	1	183	607,506	222,964	880	831,350
1916	.....	.....	17	.....	17	38,500	619,326	.....	657,826
1917	35	236	12	.....	283	207,794	2,044,560	.....	2,310,594
1918	267	463	146	313	1,189	748,126	2,477,008	226,320[a]	3,421,454

[a] From India direct.

COMPARATIVE VALUES OF IMPORTS, 1913–1918
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Corundum.	Emery.	Combined Value.	Artificial Abrasives.
1913	$165,588	$380,585	$546,173	$190,290
1914	100,798	330,721	431,519	233,799
1915	63,615	177,099	240,714	255,474
1916	30,104	248,808	278,912	547,948
1917	156,444	55,706	212,150	1,370,063
1918	308,867	165,636	474,503	1,856,734[a]

[a] Chiefly from Canada, small amounts from England and France.

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ABRASIVES EXPORTED FROM THE UNITED STATES (a)

	1914.	1915.	1916.	1917.	1918.
Wheels, emery and other.....	$572,218	$1,200,421	$2,240,227	$4,881,600	$3,862,531
All others.....	1,123,505	1,403,796	2,035,951	1,941,512	1,982,822
Totals.....	$1,695,723	$2,604,217	$4,276,178	$6,823,112	$5,845,353

(a) Bureau of Foreign and Domestic Commerce. Fiscal years ending June 30.

Abrasive exports from the United States in 1918, largely manufactured, went chiefly to France and England, but considerable amounts were shipped to Italy, Canada, and Japan, and smaller amounts to many other countries.

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Garnet

By D. H. Newland

A further decrease in the sales of abrasive garnet was reported last year. The total quantity placed on the market was 4696 short tons, compared with 4995 short tons in the preceding year and 6171 tons in 1916. On the face of the returns it might appear that the industry itself had received a setback through some untoward circumstance or that the demand for garnet as an abrasive was decreasing; actually the trade conditions were quite favorable and the falling off may be explained by the temporary inability of producers to supply the material in such quantity as the consumers required. For this condition the difficulties of securing adequate supplies of fuel, as well as labor troubles, may be held responsible. The prices obtained for crushed garnet showed a gain that more than made good the effects of the decreased output in the total value of the sales, which was returned as $248,161, or an average of $52.70 a ton, against a value of $198,327 and an average of $39.70 a ton in 1917.

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MARKETED PRODUCTION OF ABRASIVE GARNET IN THE UNITED STATES (a)
(Short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1907	7058	$211,686	1913	5308	$183,422
1908	1960	64,620	1914	4231	145,510
1909	2972	102,315	1915	4301	139,584
1910	3314	113,574	1916	6171	208,850
1911	4076	121,748	1917	4995	198,327
1912	4947	163,237	1918	4696	248,161

(a) U. S. Geol. Surv.

The Adirondack garnet mines contributed the larger part of the output, as heretofore, with smaller quantities reported from the mines in New Hampshire and North Carolina. In the Adirondacks the North River Garnet Co., H. H. Barton & Son Co., and the Warren County Garnet Mills, all engaged in operations in the same district, which is centered about North Creek, Warren County, were the active producers. A description of their deposits and the methods used in extracting and preparing the garnet has been given in earlier volumes of MINERAL INDUSTRY.

The only new development to be noted was the reopening of the Crehore mine by the American Glue Co., which began preparations for erecting a mill and starting operations on a considerable scale. The mine is in the same general region as the others, but about 10 miles from North Creek on the Indian Lake road, in Essex County. The deposit consists of a band of garnetiferous hornblende gneiss, which outcrops on the side of Casey Mountain, just north of the highway; the exposure is 40 ft. or so in width and traceable for about 2000 ft. on the strike. In general character the occurrence resembles the deposit on Gore Mountain under operation by H. H. Barton & Son Co., where the garnet is found in masses up to a ton or more in weight within a black hornblende rock that forms a distinct band within the lighter-colored feldspathic country gneiss. In the Crehore mine the garnet forms crystals and rounded masses up to 6 or 8 in. in diameter. The deposit has been worked in past years only in a small way by hand-picking and cobbing. The new project means a considerable increase in the potential capacity of the district.

Practical Features.—The utility of garnet for abrasive uses depends upon the combination of several qualities, in regard to which there is great variation in separate occurrences of the mineral. Garnet includes a number of individual species that differ in chemical composition and general appearance, but are alike in crystal habit and internal structure. The same species of garnet may also show important differences in those physical qualities which are important in determining its adaptability

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to use. Almandite, the iron-aluminium variety, is the kind mainly employed as an abrasive and ordinarily has a hardness on the Mohs scale of 7 to 7.5. It is thus superior to quartz but inferior to corundum among the common abrasives. Tests of Adirondack almandite, fresh from the rock and with crystal development, have shown the hardness to be somewhat higher than the value commonly assigned to the mineral and to lie between 7.5 and 8. Aside from hardness the quality of toughness is important, as it has a direct bearing upon the rate of wear and the ability of the abrasive to stand up under hard service. A material may be hard, but too brittle or crumbly in texture to serve the purpose. In this respect garnet shows even greater variation than in regard to hardness. The toughness is weakened by impurities that are not infrequently to be found in the garnet, particularly by the presence of such minerals as chlorite and mica which by their scaly habit introduce planes of weakness along which the mineral may be readily broken or split. Some garnet contains so much micaceous impurities as to be worthless for practical purposes. Another factor that influences the service to be expected from abrasive garnet relates to the incipient cleavage which nearly all crystal garnet possesses and which becomes apparent when the garnet is crushed. This capacity for breaking with a smooth surface is an advantage, provided it is not too well developed; it produces particles with sharp chisel-like edges that are very effective in cutting and abrading the softer materials like leather and wood, for which garnet is mainly employed. Color is not a criterion of the quality of garnet, but abrasive manufacturers express a preference for the true garnet shade, which shows up better when applied to paper or cloth than the paler sorts.

Spanish Garnet.—The only competitor of American garnet of any importance is Spanish garnet, which has appeared in the market during the last few years. It is reported to come from placers and is rather fine in grain, so that it does not yield the full assortment of sizes required for abrasive papers; it is sold at prices considerably under those obtained for the domestic product. The imports of this garnet in 1917 were valued at $14,456, the tonnage not being stated.

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ALUMINIUM

By J. W. Richards

The year 1918 was a disturbed and irregular year for aluminium. It is estimated that 90 per cent. of the total production was turned from the uses of peace to the purposes of war. In tonnage produced, aluminium now stands fourth among the non-ferrous metals, being exceeded only by copper, zinc and lead. It surpasses tin, now, by a good margin, and will undoubtedly overtake lead and zinc in the course of time; let us hazard the guess that lead will be overtaken by 1930 and zinc by 1940. In variety of uses, and importance of its functions, it is probably true at the present time that aluminium is surpassed only by iron and copper. The dreams of Henri St. Claire Deville are coming true.

Aluminium did not escape the attention of government price regulators in 1918. The demand outside of government contracts was so far from being met by the supply that its price would have soared, much to the detriment of the industry in general, if it had not been fixed. Early in 1918 the price was in France 6.40 francs per kilo, or 58 cts. per lb.; later in the year it was fixed by the French Government at 4.80 francs, or 43.5 cts. per pound. In England it was fixed at £150 per ton (33 cts. per pound). In the United States the price-fixing committee of the War Industries Board agreed with the producers on 33 cts. per lb. on lots of 50 tons or over, for 98–99 per cent. ingot metal, which agreement was approved by the President. This price was made effective from June 1, 1918, to Mar. 1, 1919. The conditions imposed by the Government on the producers were as follows:[1] "First, the producers of aluminium will not reduce the wages now being paid; second, aluminium shall be sold to the U. S. Government, to the public in the United States and to the Allied governments at the same maximum base price; third, the producers will take the necessary measures under the direction of the War Industries Board for the distribution of aluminium to prevent it from falling into the hands of speculators who might increase the price to the public; and, fourth, they will pledge themselves to exert every effort necessary to keep up production so as to insure an adequate supply during the war."

Under these conditions of government supervision and control, immense quantities of aluminium were put to military uses. It has been estimated[2] that the Allies put 90,000 metric tons of it into airplanes alone in 1918, while the Central Empires probably put 15,000 tons to the same use, which was all the output at their disposal. The *Engineering*

[1] *Eng. Min. Jour.*, June 8, 1918.

[2] *Jour. du Four Electrique.*

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and Mining Journal[1] summarizes such military uses, aside from explosives and illuminating shells, as follows:

"Substantially one-third of the weight of the Liberty motor was composed of aluminium, used wherever possible, for engine-beds, crank-cases, pistons, oil-pumps, camshaft-housings, etc. Forty separate parts of the Liberty motor alone were of aluminium. It was also used for the gasoline tanks, fuselage, hoods, cowling, seat backs, and aileron frames; in wireless telegraph and telephone, barometer cases, camera parts and in range finders. Observation balloons have the exterior painted with aluminium paint, its reflecting power reducing changes of temperature in the interior. Other uses are mess equipment for the soldier, water bottle, identification tag, and parts of gas masks."

Under the circumstances, the greatest possible production from existing plants was secured, in order to meet the necessities of the military and to keep the users of aluminium in civil industries partly supplied. What will happen to the industry now that the war has ceased is one of the great metallurgical questions of the hour. A British editor (*The Mining Journal*) sees relief in the great demand which must arise from ordinary industries, whose activities have been so greatly limited during the war, and particularly from new hydroelectric installations requiring large quantities of long-distance transmission line. In the writer's opinion, if the production is largely in excess of the demand, which is questionable, a lowering of price to approximate a small but fair profit above cost price would bring to the producers all the demand they could possibly handle—perhaps far more. The days of selling at 100-per cent. profit should be regarded as past, and any complaint of lack of demand can be quite properly answered by the suggestion of reasonable reductions in the selling price.

IMPORTS OF ALUMINIUM INTO THE UNITED STATES 1913–1918
(By fiscal years ending June 30)

Country from Which Exported.	1913. Pounds.	1914. Pounds.	1915. Pounds.	1916. Pounds.	1917. Pounds.	1918. Pounds.
Austria-Hungary	1,041,030	1,300,717	264,552	*Nil.*	*Nil.*	*Nil.*
Belgium	834,928	227,563	194,708	*Nil.*	*Nil.*	*Nil.*
France	2,580,447	2,081,468	1,798,127	*Nil.*	*Nil.*	*Nil.*
Germany	8,314,908	1,632,226	11,133	*Nil.*	*Nil.*	*Nil.*
Italy	720,992	8,816	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Netherlands	482,122	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Norway	380,800	1,173,800	2,046,168	*Nil.*	*Nil.*	*Nil.*
Portugal	*Nil.*	*Nil.*	4,321	*Nil.*	*Nil.*	*Nil.*
Switzerland	1,058,208	2,612,747	264,552	*Nil.*	*Nil.*	*Nil.*
United Kingdom	4,822,180	2,110,257	1,675,616	21,876	120	*Nil.*
Canada	6,722,401	4,816,067	7,499,313	8,148,309	1,879,859	1,498,255
Mexico	*Nil.*	*Nil.*	*Nil.*	1,521	11,792	220
Central America	*Nil.*	*Nil.*	*Nil.*	528	955	78
West Indies	338	381	150	2,043	6,655	4,949
South America	*Nil.*	*Nil.*	6,532	26,251	4,619	*Nil.*
Other Countries	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	274
Total	26,958,354	15,964,042	13,765,172	8,200,528	1,904,000	1,503,776

[1] Feb. 1, 1919.

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PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Visible Supply. (b)
				Crude.		Mfrs.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Value.	Value.	Pounds.
1903	7,500,000	$2,325,000	$0.31	498,655	$139,298	$4,273	$157,187	8,000,000
1904	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	8,216,000
1905	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	11,880,000
1906	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	15,121,000
1907	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	26,872,000
1908	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	13,465,000
1909	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	20,110,000
1910	12,000,000	2,736,000	0.228	12,271,277	1,844,830	.....	949,215	24,271,000
1911	(c)28,600,000	5,720,000	0.20	(d)4,173,308	598,272	(d)63,899	1,158,603	32,773,000
1912	(c)40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	62,760,000
1913	(c)64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	88,086,000
1914	(c)90,000,000	16,740,000	0.186	16,241,340	2,729,383	1,308,036	1,546,510	106,241,000
1915	(c)99,000,000	31,581,000	0.319	8,534,834	1,511,988	301,863	3,682,117	107,535,000
1916	(c)139,000,000	47,260,000	0.34	6,646,385	1,729,298	55,864	15,419,134	145,646,000
1917	(c)200,000,000	74,000,000	0.37	58,703	18,084	57,461	14,586,467	(f)200,059,000
1918	(c)225,000,000	74,250,000	0.33	1,800,436	569,150	39,114	10,869,388	226,800,000

(a) Not reported. (b) Production plus imports. (d) From July 1 only. (e) Estimated. (f) Included 9,470,206 lb. of ingot metal and alloys, and 550,198 lb. of plates and sheets, valued at $4,571,193, during the last half of the year.

Statistics are still almost impossible to get. It is a standing discredit to the larger producers of aluminium that either for purposes of deceiving each other, or hood-winking the governments they work under, or misleading the public, they refuse to state publicly the true extent of their business. Such a policy, pursued steadily for several years, has alienated from them the sympathy of the public and legislators when these companies ask for governmental favors, and has thus cost them in real money far more than they could possibly have lost by a proper policy of non-concealment. The aluminium industry should be conducted as openly and fairly as the steel or the copper industry, and the public has a clear right to know the real facts—particularly when favors regarding price-fixing, tariff adjustments, water-power concessions, etc., are being asked from the people's representatives in the government.

Using the best information to be had, we estimate the production of 1918 as follows:

	Pounds.	Metric Tons.
United States	225,000,000	102,000
Canada	33,000,000	15,000
France	48,400,000	22,000
Switzerland	33,000,000	15,000
Austria	17,600,000	8,000
Italy	17,600,000	8,000
Great Britain	30,800,000	14,000
Norway	39,600,000	18,000
Germany	44,000,000	20,000
	489,000,000	222,000

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Distributing this production by the firms engaged in the business, we have:

	Metric Tons.
Aluminum Company of America, Northern Aluminum Co. of Canada	117,000
British Aluminium Co. (Great Britain and Norway)	19,000
The Aluminium Corporation, Limited	3,000
L'Aluminium Francaise (France and Norway)	32,000
Aluminium Industrie Aktien Gesellschaft (Switzerland and Austria)	23,000
Hoyang Falden Norsk Aluminium (Norway)	.....
L'Aluminio Italiano (Italy)	8,000
German Government Works	20,000
	222,000

ESTIMATED WORLD'S PRODUCTION OF ALUMINIUM
(In metric tons)

Year.	Austria.	Canada.	France.	Germany.	Great Britain.	Italy.	Norway.	Switzerland.	United States.	Total.
1913	5,000	5,916	15,000	.....	10,000	(a) 874	2,500	10,000	29,500	78,790
1914	4,000	6,820	12,000	.....	8,000	(a) 937	2,500	10,000	40,600	84,857
1915	2,500	8,490	7,500	.....	6,000	(a) 904	3,500	12,500	45,000	86,394
1916	5,000	8,500	20,000	.....	4,000	(a)1,126	16,000	15,000	63,000	112,626
1917	5,000	11,800	20,000	.....	6,000	(a)1,740	18,000	15,000	90,700	170,740
1918	8,000	15,000	22,000	20,000	14,000	8,000	18,000	15,000	102,000	222,000

(a) Official statistics.

UNITED STATES PRODUCTION AND IMPORTS OF ALUMINIUM SALTS
(In short tons)

Years.	Production.						Imports. (a)	
	Alum.			Aluminium Sulphate.			Quantity.	Value.
	Quantity.	Value.	Per ton.	Quantity.	Value.	Per ton.		
1910.....	9,090	$300,763	$33.09	126,792	$2,447,552	$19.30	2,127	$53,671
1911.....	10,468	329,686	31.49	134,077	2,743,336	20.46	2,283	56,833
1912.....	9,246	293,995	31.80	150,427	2,909,495	19.34	3,342	84,606
1913.....	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549
1914.....	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915.....	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916.....	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917.....	19,714	1,017,083	51.60	178,738	5,746,472	32.15	507	39,088
1918.....	.....	.....	.....	.....	.....	.....	233	16,635

(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate, aluminous cake, and alum in crystals or ground.

United States.—All the plants of the Aluminum Co. of America, the sole producer, were run to full capacity the whole year. The Canadian Government agreed to permit an ice dam to be built across the south branch of the St. Lawrence River, near the inlet to the power canal which terminates at Massena, N. Y. It is estimated that this ensured an addition of 20,000 hp. to the plant's usual power supply during the winter months, and increased the annual output of aluminium some 3000 tons. There was no change in the plants at Niagara Falls; the Power Commission continued them in full operation because of being on war supplies. The southern plant at Maryville, Tenn., worked at capacity all year;

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the plant at Badin was in full operation from June. The great development on the Little Tennessee River is still in course of construction, the dam at Cheoah being 75 per cent. completed; it is expected that power from this power station will be transmitted to Maryville in 1919, and a larger number of reduction buildings are being erected there to utilize it.

Rumors were rife of new companies entering the aluminium business, one to utilize the alumina from the Marysvale, Utah, alunite deposits, another to operate a new process at Niagara Falls, but nothing came of either.

The *Metal Bulletin* (London) estimates the 1918 production at 250,000,000 lb.; we regard this as probably too high. The United States Geological Survey reports the *value* of the 1918 production as $41,159,225; we regard this as too low, unless by *value* is meant the cost to the manufacturers and not the average selling price or the average cost to the consumer.

Canada.—Nothing new transpired during the year other than the use of all the power available at Shawinigan to turn out a maximum output.

France.—We have not been able to get detailed information concerning the French works. They were presumably all working to full capacity, at least until the armistice was declared in November. The Norwegian works of the Aluminium Francaise were run intermittently, being troubled much by labor strikes.

Great Britain.—The British Aluminium Co. made profits in 1918 of £420,426, after deducting excess profits taxation. The dividend for the year amounted to 10 per cent. The output in 1918 was "the largest in the company's history," but the amount of it was carefully concealed, even from the stock-holders, and after the ending of the war. Production has been curtailed since the armistice, and large stocks have accumulated because of cessation of Government demand. Arrangements have been made with the Government whereby the large stocks on its hands will be gradually reduced so as not unduly to depress the industry. The great demands which had arisen during the war would certainly lead to a permanently greater application and consumption of aluminium in the near future, which would require further increase of productive capacity.

The Aluminium Corporation, Ltd., of Dolgarrog, North Wales, produces billets, ingots, sheets, granulated and powdered aluminium. They operate bauxite mines at Sillans, Department of Var, France, and refine it to alumina at Hebburn-on-Tyne. Their present hydraulic installation is 9000 kw., but is being largely increased by dams under construction which will give a storage capacity of 1,000,000,000 cubic feet. The output

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for 1918 is not furnished, but should be, using the power stated, about 3000 metric tons (6,600,000 lb.).

Norway.—The operation of some of the works to full capacity was interfered with by labor troubles and shortage of alumina. The works of the Norsk Aluminium at Hoyang is said to be operating only its electrode factory; the rolling and drawing mill is not yet in operation. The production of aluminium by Det Norsk Nitrid at Tyssadal and Arendal was greatly interfered with by strikes. The electrode works at Arendal was started toward the end of the year. Norsk Elektrokemisk is introducing a new process of producing alumina (see further under "BAUXITE"), which is hoped to relieve the shortage and render Norway independent of importations of this basic material. The works of the British Aluminium Co. at Vigeland and Stangfjord ran steadily at their normal capacity.

Switzerland.—No reports of the business or profits of the Aluminium Industrie Aktien Gesellschaft during 1918 have come to hand. While exports in 1917 were 11,000 tons, almost all to Germany, the 1918 exports are given as only 7300 tons. Whether this indicated lack of raw materials or simply that Germany was producing most of its own requirements, we do not know. It is reported that several new aluminium works were planned in Austria and Hungary before the war closed; the Austrian were probably extensions controlled by the Swiss company.

India.—The high-alumina deposits in India known as laterite have again given rise to rumors of domestic aluminium works. At the suggestion of the Indian Government, Tata, Sons & Co. of Bombay decided to utilize the headwaters of the Koyna River in the Western Ghats, which later joins the Krishna River. A dam is to be built across a valley, producing a lake with an area of 57 sq. mi. and a storage capacity of 132,000,000,000 gallons. A head of 1700 ft. can be utilized, giving 300,000 to 350,000 horsepower. The current would be transmitted to the coast, where factories would be erected at Jaigarh to make aluminium and other electrochemical products.[1]

Australia.—The Electrolytic Zinc Co. announces that it will erect at Hobart, Tasmania, aluminium works with an annual capacity of 4000 tons, in order to supply domestic consumption. Other electrochemical plants are projected at the same place.

Germany.—The *Echo des Mines* describes some of the developments in producing aluminium in Germany in 1918. Supplies of bauxite, mostly of low grade, were obtained in Dalmatia, Hungary, Hesse, and in the Eifel region near Cologne (volcanic formations). The first works started was at Erftwerk, near Cologne, erected by the Aluminium In-

[1] *Min. Mag.*

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dustrie Aktien Gesellschaft of Neuhausen, Switzerland. Electric power for this plant was transmitted at 150,000 volts from steam-turbine power stations at Knap-Sack, near Cologne, and at Reisholz, near Dusseldorf. An electrode factory was built at Erftwerk. The pure alumina was manufactured by the Giulini, Curtius, and Rhenania firms.

Another aluminium plant was erected by the Electrometallurgische Werke Ah. Horrem, near Cologne (supplied with power by the Cologne power station, at 25,000 volts). This is an offshoot of the Griesheim works, which has an alumina plant in Silesia. The Curtius works at Duisburg and the Ichenborf plant are also mentioned as producing aluminium. The Neuhausen company erected an alumina works near Berghien, west of Cologne, with a capacity of 50 to 60 tons of alumina per day, using the poor lignites of this district for fuel. Fifty tons of alumina per day would be 18,000 tons per year, containing over 9000 tons of aluminium. Since the Giulini firm at Mundenheim largely increased its alumina capacity during the war, and the Rhenania firm at Honningen, near Coblenz, as well as the Curtius firm, were producing alumina, it may be inferred that at least 40,000 tons of alumina was produced in Germany in 1918, corresponding to an output of 20,000 tons of aluminium. The immense quantities which they used during the year in airplane construction alone would seem to confirm this estimate.[1]

The Krupp interests were said to have under construction a large aluminium plant in Silesia, which was not completed when the armistice was signed.

Manufacture

O. Nissen[2] describes manufacturing processes used in Europe. His article contains many mis-statements, such as: "Electrolysis of alumina dissolved in cryolite was well known by Deville and others." Some pertinent facts, however, are given, from which we abstract the following:

Electrodes should not contain more than 1 per cent. of ash. Coal or coke is not pure enough, natural graphite or baked carbon is not pure enough; retort carbon is sufficiently pure. In general, petroleum coke is the best material, its ash content being 0.1 to 0.4 per cent., seldom over 0.5 per cent.

The aluminium pots take 6.5 to 7.5 volts. Thirty to forty are connected in series. The current is usually 8000 to 10,000 amperes; in some cases 15,000 to 20,000. Furnaces are tapped every third or fourth day.

Using three-phase current supply, synchronous converters are mostly used in America and England and motor-generators on the Continent.

[1] Most of the above facts were taken from the *Mining Journal*.
[2] *Teknisk Tidskrift*, Aug., 1917; *Chem. Met. Eng.*, Dec. 15, 1918.

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Recent tests on the melting point of the electrolyte used have shown:

Cryolite	1000° C.
Cryolite + 3 per cent. alumina	974° C.
Cryolite + 4 per cent. alumina	960° C.
Cryolite + 5 per cent. alumina	915° C.
Cryolite + 6 per cent. alumina	960° C.
Cryolite + 7 per cent. alumina	982° C.
Cryolite + 8 per cent. alumina	992° C.
Cryolite + 9 per cent. alumina	980° C.
Cryolite + 15 per cent. alumina	994° C.
Cryolite + 20 per cent. alumina	1015° C.

Between 8 and 9 per cent. alumina there is an apparent break in the curve, probably caused by a change in the composition in the bath. If AlF_3 is added the melting point will drop still further. With 20 to 30 per cent. Al_2O_3, the bath becomes thicker and Al_2O_3 separates out on the bottom. If the temperature of the bath is too high, Al_4C_3 may form, in yellow hexagonal plates.

If run between 800 and 1000° C., some CO_2 is formed at the anodes, 5 to 10 and even 20 parts of CO_2 to 100 parts of CO.

Some SiF_4 may be evolved from the bath, blackening the copper busbars, and whitening the glass of the shop.

Twenty-five kw.-hr. may produce 1 kg. of aluminium, but 33 to 35 kw.-hr. is the more frequent value. The electrode consumption is 0.7 to 0.9 kg. per kilogram of aluminium.

The cost per pound may be itemized as follows:

	Cents.
16 kw.-hr. @ 0.14 cts.	2.24
2 lb. Al_2O_3 @ 2.27 cts.	4.54
0.8 lb. electrodes @ 3.18 cts.	2.54
0.12 lb. cryolite @ 3.64 cts.	0.44
0.05 lb. Al fluoride @ 4.54 cts.	0.27
0.15 working hours @ 5.12 cts.	1.38
Miscellaneous	1.38
	12.79

G. Guilini proposes to reduce Al_2O_3 by C in a vacuum,[1] thus removing the CO gas as quickly as it is formed and preventing it from re-oxidizing the aluminium. Curiously enough, he states that the aluminium is also produced as vapor, and is therefore quickly removed by the high vacuum from the neighborhood of the carbon reducing agent, and thus the formation of aluminium carbide is prevented. He must use a wonderfully discriminating vacuum.

P. R. Hershman of Chicago reduces alumina by carbides.[2] The mixture is pressed into the form of a resistor, with some metallic filings or chips included to keep the conductivity, and heated by an electric current in an atmosphere of hydrogen or hydrocarbons. The resulting metal "may be tapped shortly after its formation." Doubtless it can, if it ever appears; yet we have forgotten—there was finely divided aluminium put into the mix.

[1] U. S. Patent No. 1257995, Mar. 5, 1918.
[2] U. S. Patent No. 1273220, July 23, 1918.

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Working

Purification.—The *Chemical Trade Journal*[1] records experiments by by F. Milius of the Berlin Reichanstalt, to the effect that silicon can be removed from aluminium by fusing it under sodium nitrate. No further details are given; the statement needs confirmation. The further statements are made that when aluminium containing 16 per cent. of iron was chilled and treated with dilute hydrochloric acid the iron was reduced to 0.1 per cent., but only 20 per cent. of the aluminium was recovered. A more promising idea is that aluminium surfaces which had taken up iron during manufacture were successfully freed from iron by use of dilute hydrochloric acid.

Hardening.—The annual statement is made that some method of hardening the pure metal has been found. This time, according to the *Salt Lake Mining Review* of July 30, 1918, it is Tilman White, a millwright of Oakland, Calif., who has succeeded by special treatment in raising the tensile strength to 40,000 lb. per square inch. Whether this is by heat treatment or by alloying with a hardening metal is not stated.

Annealing.—R. J. Anderson describes[2] interesting results obtained on cold-rolled aluminium sheets by exceedingly brief exposures to annealing temperatures. The usual practice is to anneal 18 to 30 hr. at 375° C., reducing the "Shore scleroscope" hardness number from 13–15 down to 4–5. In this operation, however, the sheets are often over-annealed, microscopic investigation showing unusually coarse grain structure, and the metal is liable to go to pieces in the drawing press. Annealing of this metal (which had been reduced 72 per cent. by cold rolling) for 2 hr. at 400° C. entirely removed the difficulty. Annealing for 3 min. only, at various temperatures, showed the following range of hardness tests:

Time, Minutes.	Temperature, Deg. C.	Shore Scleroscope Number.	Erichson Test, Indentation, Mm.
3	200	15.0	7.90
3	250	14.0	8.60
3	300	14.0	8.75
3	350	13.0	8.93
3	400	12.0	9.09
3	450	9.0	9.52
3	475	5.5	10.05
3	490	5.5	10.70
3	500	4.5	10.64
3	550	4.5	11.00
3	600	4.5	11.10

These tests show the plates made as soft as it is possible to make them by 3 min. annealing at 500° C.; 8 min. at 450° C. produced a similar effect. All the blanks treated at these temperatures worked properly in the drawpress. It is thus proved that very great saving in time and expense is possible by annealing at higher temperatures than are now practised.

[1] 64, 165 (1919).

[2] *Iron Age*, July 18, 1918.

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L. H. Whitney[1] heats the articles quickly to a temperature above 370° C., but not over 450°, and keeps them there 2½ to 3 hr., then cools them quickly, as by quenching in water or blowing air on them. It is stated that this treatment converts the graphitoidal silicon present as an impurity into uniformly dissolved silicon, and gives maximum annealing effects.

Melting Scrap.—Charles Vickers gives some interesting information about the reclaiming of scrap aluminium, which became an important item during the war when the ingot metal was so scarce.[2] Loose clippings should be briquetted into dense lumps, in order to get a satisfactory weight of metal into the furnace. Wire in the form of cable can be cut into suitable lengths, but should not be allowed to untwist. Loose wire in short lengths costs considerable to re-melt, with a loss of some 7 per cent. Zinc chloride (?) is recommended as flux to separate oxide from the metal; with a high-zinc alloy, salammoniac.

Alloys

Paul D. Merica[3] publishes a valuable compilation of the literature of aluminum and its light alloys.

Circular No. 76 of the Bureau of Standards[4] contains 120 pages on "Aluminum and its Light Alloys," describing their physical and chemical properties. The compilation is fairly well done.

Zeppelin Alloy.—A piece of alloy taken from a smashed Zeppelin in England contained 91.92 per cent. Al, 4.13 Cu, 3.27 Fe and 0.65 Si. The only remarkable constituent is the iron, which is much higher than has been used before in such alloys. Its tensile strength was 40,000 lb. per square inch.

Ferro-aluminium.—J. W. Richards, in the course of an address on ferro-alloys, at the Fourth National Exposition of Chemical Industries, called attention to the possibility of making 50-per cent. ferro-aluminium in electric furnaces similar to those now used for 50-per cent. ferrosilicon. He estimates the cost of such alloy at $100 per ton, furnishing the contained aluminium at 10 cts. per lb. instead of the 30 cts. which the steel industry now pays for No. 2 grade metal. Such alloy could be made directly from crude bauxite and iron ore, or from the red bauxite rich in iron found abundantly in southern France and Austria.

Aluminium Bronze.—W. M. Corse gives the following aperçu of the physical properties of bronze containing 10 per cent. aluminium and 1 per cent. iron:[5]

[1] U. S. Patent No. 1273706; July 23, 1918.
[2] *Met. Market Rept.*, Aug. 12, 1918.
[3] *Chem. Met. Eng.*, **19**, 135, 200, 329, 587 (1918).
[4] Washington, Apr. 21, 1919; price, 20 cents.
[5] *Bull. Am. Inst. Min. Eng.*, **144**, 1738 (1918); *Trans.*, **60**, 171.

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Ultimate tensile strength, lb. per sq. in.	65,000–80,000
Ultimate tensile strength, kg. per sq. cm.	45.5–56.0
Yield point, lb. per sq. in.	23,000–28,000
Yield point, kg. per sq. cm.	16.1–19.6
Elongation in 2 in. (5 cm.), per cent.	20–30
Reduction to area, per cent.	21–29
Specific gravity at 20° C.	7.5
Brinell hardness number (500 kg. load for 30 sec.)	92–100
Pattern maker's allowance for shrinkage, in. per ft.	0.22
Pattern maker's allowance for shrinkage, percentage	1.8
Weight per cu. in., lb.	0.27
Compression, elastic limit, lb. per sq. in.	19,000
Compression, elastic limit, kg. per sq. cm.	13.3
Coefficient of friction	0.0025
Modulus of elasticity, lb. per sq. in.	15,000,000–18,000,000
Modulus of elasticity, kg. per sq. cm.	10,500–12,600
Resistance to impact, Fremont notched-bar test (fractured section 7 by 10 mm.) kg.-meters	7–10
Endurance of alternating impact, Landgraf-Turner or Arnold test, alternations	3,500–5,500
Resistance to shear by impact, McAdam machine, ft.-lb.	750–850
Resistance to shear by impact, McAdam machine, kg.-m.	104–118

Giesserei Zeitung states[1] that with bronze over 7 per cent. aluminium special heat treatment improves the properties greatly. With 10 per cent. aluminium, heated to 800° C. and quenched, it shows hardness 100 to 200 Brinell, according to its cross-sectional area. Bronze thus hardened is a good bearing metal for speeds up to 20,000 r.p.m. The following table gives the mechanical properties attained, the special heat treatment consisting in quenching from temperatures below 800° C.

	Limit of Elasticity, Kg. per Sq. Mm.	Tensile Strength, Kg. per Sq. Mm.	Extension, Per Cent.	Contraction, Per Cent.	Hardness, Brinell.
Original alloy (cast)	9.6	59.80	19.5	23.7	100
Original alloy (quenched)	19.8	73.64	1.0	0.8	262
Special heat treatment	27.7–19.2	67.69–64.14	5.5–14.0	9.1–18.5	158–140

H. Rix and H. Whitaker read a paper[2] before the British Institute of Metals describing Die Casting of Aluminium Bronze. This has been attempted for many years, but has only lately been successful. The alloy used contains 7 to 10 per cent. aluminium and 1 to 4 per cent. iron. The function of this rather larger proportion of iron is to form a skeleton or matrix of the high-melting-point compound $FeAl_3$, which solidifies first and thus reduces the shrinkage and produces a fine grain. The iron also increases the yield point and ultimate strength, so that the casting does not pull itself apart while cooling in the die. Iron should be added as pure iron chips; no silicon at all should be put into the alloy. The dies should be of chill-cast, close-grained, gray cast iron, as hard as can be machined. If low in combined carbon it will not "grow" during use, and will stand five to seven thousand casts. No facing is used on the die. The core-plugs are chromium-tungsten steel,

[1] *Metal Ind.*, April, 1919.

[2] *Chem. Met. Eng.*, Feb. 1, 1919.

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and are dipped in a graphite wash as soon as withdrawn. Cores must be removed at just the right time, to avoid rupture of the metal around them. A casting made in a 1-in. chill had the following physical properties:

Diameter of test piece	0.564 in. (14.1 mm.)
Yield point	29,400 lb. per sq. in. (20.6 kg. per sq. mm.)
Ultimate tensile strength	71,000 lb. per sq. in. (49.7 kg. per sq. mm.)
Elongation in 2 in. (5 cm.)	24.0 per cent.
Reduction of area	21.8 per cent.

The authors point out that a proper scientific study of the problem of die casting any alloy requires an investigation of its coefficient of expansion at different temperatures, fluid and solid; its thermal conductivity; its specific heat; its mechanical properties at high temperatures; its mass, volume, and surface area when cast; its metallography; its pressure on the die; and its fluidity—all of which is very true and pertinent

Bauxite in the United States

By T. Poole Maynard

Introduction.—Bauxite is an aluminium-iron hydrate. It occurs in concretionary forms and grains, and the mineral takes its name from its typical occurrence in the vicinity of Beaux, France. The pisolitic and oölitic character of bauxite is apparently as unique a characteristic as the crystal rhombohedron is a characteristic of calcite. The chemical composition of bauxite varies in the content of alumina, silica, iron oxide, titanium and combined water, and the manufactured products which are made from these ores utilize practically all of the different types which occur in nature.

Bauxite is a secondary mineral derived originally from clay or some rock of high alumina content. The alumina content of most of the original rocks is present in the form of silicate of alumina, and in nearly all cases the bauxite has been formed by the alteration of the original deposit in which the silica has been replaced by oxygen with the concentration of the alumina and iron oxide, and the content of silica contained in the bauxite is dependent upon the chemical reactions which have taken place, in some cases resulting in an almost complete replacement of the silica, while in other cases a large amount of silica is present.

Occurrence.—Bauxite in commercial quantity is confined in the United States to Arkansas, Georgia, Alabama and Tennessee, but is known to be present in some quantity in Viriginia and New Mexico. The States which lead in the production of bauxite are named above in the order of the relative importance of the deposits.

Arkansas.—The Arkansas deposits were first discovered by Dr. J. C. Branner, who was associated at the time with the Arkansas Geological

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Survey, about 1887. The Arkansas deposits are closely associated with syenites, intrusive deposits which are overlain by tertiary materials. Approximately 80 per cent. of the bauxite produced in this country has been mined in the Arkansas field. The American producers have concentrated to a large extent in this field on account of the ease of mining operations.

These ores are comparatively high in iron, but are also high in alumina. The principal areas in the Arkansas field are known as the Pulaski and Saline County areas. In the Saline County field the deposits are found in the vicinity of Bauxite or Bryant, at a point about 22 miles southeast of Little Rock, in what is known as the Bryant Township. In Pulaski County the ores occur immediately south of Little Rock.

Georgia.—The first bauxite deposits found in the United States were those in the Rome district of Georgia. The North Georgia deposits are similar in origin to those of North Alabama and Tennessee.

About 1907 bauxites were found in the Central Georgia section at a point 15 or 20 miles east of what is known as the "Fall Line." This Fall Line separates the Piedmont plateau in Georgia from the Coastal Plain area, which consists essentially of sands and clays with some limestone; and in this area the clays have altered in some places *in situ*, while at other points the bauxites have been formed and transported and redeposited before deposition of the present overlying formations.

The bauxites in South Georgia are found near the Alabama line, extending in a general northeast direction to a point 20 miles or more northeast of Macon. They are usually overlain by clays, sands and bauxitic clays, almost universally occurring above water-level, and usually occupying well-defined strata, grading into low-grade bauxites, usually in the lower portion of the bed.

There is in many cases no evidence of the presence of the bauxite in the field to the ordinary layman; but a knowledge of the presence of clays and the geological history of this particular area will indicate the possibility of the location of bauxites, and during the past few years most of the deposits which have been revealed have been found through the application of an interpretation of the origin of the deposits after carrying on a limited amount of prospecting.

The North Georgia deposits are usually high in alumina and low in silica, in some instances carrying a high content of iron, while at other points the bauxite is low in iron.

Middle Georgia deposits are almost always low in iron, carrying from 3 to 20 per cent. silica, and from 50 to 60 per cent. alumina.

A rather remarkable illustration of the possibility of the location of bauxites in Middle Georgia is represented by the fact that the only

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deposits which have been developed in Middle Georgia occur along the Central of Georgia Railway. It can be definitely stated that there is no particular reason why the Central of Georgia Railway should intercept all of the Middle Georgia deposits, but the activity taken by this railway in connection with the investigation of their mineral resources resulted in their location, while a lack of interest has left unrevealed deposits elsewhere where they might be found. Bauxites of almost every type are found in the Middle Georgia area.

Alabama.—Bauxites in Alabama are found in large lenses of clay contained in the Knox Dolomite formation of Cambro-Silurian age. The North Alabama deposits are of similar origin to those in North Georgia and Tennessee, and therefore, this description of origin will suffice for those deposits referred to above under North Georgia and referred to later on under Tennessee. Unconformities are characteristic of the Cambro-Silurian time and deposits of clay took place. Later on these clays were elevated above water-level and percolating waters carrying acids derived from organic sources and from pyrites, etc., have resulted in the alteration of the clay into the oxide of alumina with some associated impurities, such as iron, silica, etc. These deposits are also found above water-level, and are the result of percolating infiltrations from above rather than from ascending waters, as originally concluded by Hayes. The Alabama deposits are of greatest extent between Cave Springs, Ga., and Piedmont, Ala.

Tennessee.—The Tennessee deposits are of similar origin to those of North Alabama and North Georgia; deposits have been developed in the vicinity of Chattanooga and in Carter County.

PRODUCTION OF BAUXITE IN THE UNITED STATES BY STATES
(In tons of 2240 lb.)

State.	1909. (a)	1910. (a)	1911. (a)	1912. (a)	1913. (a)	1914. (a)	1915. (a)	1916. (a)	1917. (a)	1918. (a)
Alabama.	22,227	33,096	30,170	19,587	27,409	18,547	25,008	46,410	62,134	37,000
Georgia..				14,173						
Tennessee	106,814	115,836	125,448	126,105	182,832	200,771	272,033	378,949	506,556	532,000
Arkansas.										
Total..	129,101	148,932	155,618	159,865	210,241	219,318	297,041	425,359	568,690	569,000

(a) Statistics of the U. S. Geol. Surv.

USES

Bauxite is used principally in the manufacture of: aluminium (*q.v.*); abrasives (*q.v.*); salts of aluminium; refractories; explosives, etc.

Alum and aluminium sulphate are made by the admixture of bauxite with sulphuric acid. The potash alums are used in the manufacture

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of baking powder rather extensively. Aluminium sulphates are used in the purification of water, in the manufacture of paper, dyes, etc.

Bauxite has been extensively used in this country and in France for the manufacture of high-grade alumina refractories. There is an increase in the demand for bauxite refractories, particularly on account of the recent strides of the chemical industry in this country.

CONSUMPTION OF BAUXITE IN THE UNITED STATES

Year.	Production.			Imports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.
1909....	(a) 129,101	$679,447	$5.27	18,689	$83,956	147,789	$163,403
1910....	(a) 149,679	778,203	5.33	15,720	65,743	164,601	782,001
1911....	(a) 155,618	750,649	4.87	43,222	164,301	198,840	914,950
1912....	(a) 160,124	900,620	5.00	26,214	95,431	186,079	864,363
1913....	(a) 210,241	997,698	4.75	21,456	85,746	231,697	1,083,444
1914....	(a) 219,318	1,069,194	4.87	24,844	96,500	238,788	925,610
1915....	(a) 297,041	1,514,834	5.10	3,420	17,107	284,379	814,755
1916....	(a) 425,100	2,296,400	5.40	30	87	407,098	1,309,033
1917....	(a) 568,690	3,116,421	5.48	7,760	29,433	554,659	1,834,565
1918....	(a) 569,000	3,224,000	5.70	3,653	14,791	552,942	1,735,103

(a) Statistics of the U. S. Geol. Surv.

Bauxite in Foreign Countries

British Guiana.—Reports indicate that the deposits of Guiana will become of great importance in the future. Sir Walter Egerton, late Governor of British Guiana, spoke of these deposits as follows in a paper read before the Royal Society of Arts:[1] "As long ago as 1897, and again in 1910, Professor Harrison reported the existence of extensive deposits of exceptional purity. The discovery attracted little attention, however, until five years ago, when the Northern Aluminum Co. of America applied for leases of areas containing such deposits. The British Government stipulated that any company working the deposits must be under British control. Ships drawing 16 ft. can reach the workings sixty miles above Georgetown. The bauxite deposits have recently been traced almost from the Venezuelan boundary right through the colony to the Dutch border. Further deposits have been located in Dutch and French Guiana, and the Guianas probably contain the most extensive deposits in the world, and some in very accessible positions. Should the industry develop on a large scale, local electric treatment of the raw material with power obtained from one of the great waterfalls is sure ultimately to take place."

In regard to the quality of the bauxite, analyses published by the Science Department in 1917 show the ore to be rich in aluminium. The analysis of the ore from one section was given as 67 per cent. aluminium

[1] *Min. Jour.*, June 22, 1918.

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oxide, from another 64 per cent. Regarding operation of the deposits, in 1917 the Demerara Bauxite Co., Ltd., started mining work on Crown and private lands at Three Friends, Demerara River, and shipped to the United States 2037 tons of ore, on which royalty at the rate of 10 cts. per ton was paid. Large clearings for camp sites have been made at Mackenzie, Fair's Rust, and Cap-a-Star, all on the Demerara River. The ore is at present conveyed by punts to Mackenzie, where the river is navigable at all times for ocean-going steamers and where a crushing and drying plant is to be erected. About 800 men were employed, exclusive of the supervising staff. Four hundred applications for land for mining bauxite, embracing an area of 652,040 acres, were filed with the Department of Lands and Mines during the year. Applications for 200,820 acres were abandoned, withdrawn, or refused, no applications being granted until after the war.[1]

WORLD'S PRODUCTION OF BAUXITE, 1913-1917, IN LONG TONS

Country.	1913.	1914.	1915.	1916.	1917.
United States ...	210,241	219,318	297,041	425,100	568,690
France.....	304,314	(a)	(a)	(a)	(a)
United Kingdom	8,282	8,286	11,723	10,329	14,724
Italy	6,841	3,844	5,807	8,739	7,666
India	1,184	514	876	750	1,363
Total	530,862	.....	.....	.....	.....

(a) Statistics not available.

Austria-Hungary.—An extract[2] from *Die Zeit* (Vienna, Austria) states that the German aluminium factories relied mainly on Austrian bauxite during the war. Their exploitation of deposits in Dalmatia was a source of large income for that province. The ores yielded 25 to 30 per cent. aluminium. Bauxite has been obtained for years past in the northern islands of Dalmatia, but on the mainland not until October, 1916, when mining began near Sebenico. At present the work is confined to the neighborhood of Drnis. The mines farther inland are not yet worked, owing to transport difficulties. There are rich deposits near Trau. Herzegovina also is rich in bauxite, which was mined during the war by a German firm and by the Bauxite Co. of Vienna.

Germany.—Deposits are said to have been found in Alt Hesse, consisting of nodules in the basaltic flows of the Vogelgebirge, Spessart, and other mountain areas. The rock is crushed and the aluminous material floated out. Laterite deposits found at Giessen, Gruenberg, Lich and Gelnhausen contain:

	Reddish Ores.	White Ores.
Al_2O_3, per cent.....	48 to 52	57 to 74
Fe_2O_3, per cent.....	57 to 74	about 8

[1] *Comm. Rept.*, Jan. 11, 1919; Feb. 1, 1919.
[2] *Board of Trade Journal*, London, through *Comm. Rept.*, June 15, 1918.

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Other Countries.—Deposits are reported from many points in Venezuela and from the outer edges of the great bowl of the valley of the Amazon, particularly in Colombia and Ecuador.

No information is at hand concerning the important bauxite fields of France.

TECHNOLOGY

The most interesting development during 1918 has been the exploitation of the Goldschmidt process in Norway for the extraction of alumina from the native feldspar found there in great abundance and known mineralogically as labradorite. Its formula varies from $NaCaAl_3Si_5O_{16}$ to $NaCa_3Al_7Si_9O_{32}$, containing 10 to 16 per cent. CaO and 28 to 35 per cent. Al_2O_3; the Norwegian mineral is said to average 30 per cent. alumina. The Goldschmidt patents describe the treatment of the finely ground mineral by dilute nitric acid, such as is obtained by the Birkeland-Eyde electric-furnace process. This gives a solution of nitrates, from which silica and iron oxide are first precipitated. The solution is then evaporated and heated until nitrous oxide vapors are copiously given off, coming from the decomposition of aluminium nitrate, while nitrates of calcium and sodium, which are also in solution, are not decomposed. On the heated mass being thrown into water, and filtered, the alumina is recovered, while the mixture of nitrates of calcium and sodium, obtained by evaporating the solution, is a good fertilizer. It is to be hoped that the nitrous-oxide vapors driven off are also recovered and utilized.

The Norsk Aluminium, which has works at Hoyang, has an experimental alumina plant at Nidaros-Teglverk near Trondhjem, where they have manufactured small quantities of alumina directly from clay.

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ANTIMONY

By K. C. Li

Prior to the World War, now happily at an end, antimony was one of the metals about which very little was known and in which very little interest was taken, even by close students of metallurgy. The nature of the metal is such that it has been found suited to but a few purposes and no one has considered it worth while to investigate its possibilities beyond the well known uses. This is rather unfortunate, as the antimony industry is one of the few well established industries upon which depends the future of the young republic of China.

The ore is widely distributed throughout the world, being found in China, France, Italy, Africa, Germany, Hungary, Mexico, United States of America, Japan, Canada and Australia, but mining on a large scale has been carried on only in a few countries such as China, France and Mexico. In the early days of the industry in China most of the product was exported as ore or as needle antimony, which is produced by treating the sulphide ores in liquating pots and bringing them to a heat sufficient to melt but not to decompose the ores. Much of the ore and crude went to England, where it was converted into metallic antimony of a very pure brand, but during the war other brands have forced their way on the market and proved satisfactory for all purposes. Certain lead ores carry a percentage of antimony and it is also found in gold ores. The ore is found in veins and pockets and the methods of mining are similar to those employed for other minerals.

Metallurgy

There are four processes in use for the smelting of antimony ore to regulus or metal.

1. Roasting to produce the trioxide and reducing by carbonaceous fuel (French Process).
2. Blast-furnace smelting.
3. Liquation.
4. Precipitation by iron.

Each of the above methods is particularly adapted for use with certain grades of ore. The trioxide method is best for low-grade ores and on that account it is used almost exclusively in China, where the ores are very low grade. The smelters have to be close to the mines to avoid high freight charges on the poor ores. The second method is good for ores

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from 25 to 40 per cent. Sb, its chief disadvantage being high loss due to volatilization, which, it is claimed, can be reduced by using a tall chimney. The third method is suitable for very rich ores, up to 60 per cent. Sb. The process is simple, but is not at all efficient where the quality of the ore falls below 45 per cent. Sb. The last method is suitable only for very rich ores and for the reduction of antimony crude. This method is used to some extent in China also where a quantity of crude is produced and then smelted in reverberatory furnaces. The iron which is added combines readily with the sulphur, leaving a very pure metal. The refining and "starring" are generally done in reverberatory furnaces, but in some cases the refining is carried out as a separate process in graphite crucibles. The beauty of the "star" is generally taken as an indication of the purity of the antimony, although this is not necessarily true.

In order to be marketable, antimony metal must be at least 99 per cent. pure, the better brands, such as "WCC" brand and Cookson's "C" brand, running over 99.5 per cent. Many unknown, miscellaneous brands of antimony have found ready sale during the war for war purposes, but the regular consumers for ordinary purposes are now showing a tendency to demand the well known brands of tested purity.

Production in 1918

Judging from the supplies of antimony available throughout 1918, it would appear that mining had continued with unabated vigor, and this seems to be especially true of the Orient. It is somewhat surprising that this was so, because it is a well established fact that the prices ruling throughout the year were such as to allow but a very small margin of profit. Indeed it may be doubted whether there was any profit at all. It speaks volumes for the Orient and for China in particular, that in spite of sacrificial prices the supply of antimony was maintained and never at any time did it appear that the United States Government would have to fear a shortage of supply. If China had done nothing else to assist the Allied cause, we venture to say that this service of maintaining the supply of antimony was no small one.

Production in the United States.—From the information available it appears that production practically ceased in this country during 1918 and those interested in the business confined their energies to an attempt to convince the Government that the industry should be encouraged by levying a prohibitive tax on imports. According to figures of the U. S. Geological Survey the domestic production for 1918 was as follows: From foreign ores, 2490 tons; from domestic ores, 127 tons; for 1917, from foreign ores, 2182 tons; from domestic ores, 258 tons.

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ANTIMONY STATISTICS OF THE UNITED STATES
(In tons of 2000 lb.)

Year	Imports, Antimony Content.			Production. (a)			
					In Hard Lead.		
	Metal or Regulus.	Crude and Ore.	Type Metal.	From Domestic Ore.	From Domestic Ore.	From Imported Ore.	Recovered from Old Alloys, Scrap, Dross, etc.
1907	4,331	1,380	1,369	.....	1,561	.....	.....
1908	4,057	1,640	422	.....	2,246	.....	.....
1909	4,826	1,693	1,327	.....	1,617	743	1,556
1910	4,950	*Nil.*	1,109	.....	1,598	631	2,779
1911	5,479	*Nil.*	727	.....	1,543	711	2,369
1912	6,969	*Nil.*	52	.....	1,224	725	2,506
1913	7,667	25	50	.....	2,204	304	2,705
1914	6,535	993	94	.....	2,961	175	2,646
1915	8,742	1,682	172	.....	3,496(*d*)	464	3,102
1916	9,875	(*b*)4,742	119	.....	2,759(*d*)	.....	4,480
1917	17,825	(*b*)5,960	*Nil.*	258	2,566(*d*)	2,182(*c*)	4,961
1918	13,874	1,360	.....	127	.....	2,490(*c*)	.....

(*a*) Figures of U. S. Geological Survey. (*b*) Ore only. (*c*) Antimony metal. (*d*) Includes both domestic and foreign ore.

The few references made by trade papers and the Geological Survey to the domestic production all emphasize the fact that little or no interest was taken in mining. It is repor ed that only a few cars of ore were shipped from the mines in Utah, and that in Alaska mining practically ceased because of low prices. An interesting report comes from Spokane, Wash., to the effect that laboratory experiments on the electrolytic method of producing antimony had been successful and that if further tests on ore met with success a large electrolytic plant would be built. It is now very doubtful whether such an enterprise would prove profitable.

IMPORTS OF ANTIMONY INTO THE UNITED STATES
(According to the Bureau of Foreign and Domestic Commerce)
(In pounds)

Month.	1917.		1918.	
	Ore.	Matte, Regulus or Metal.	Ore.	Matte, Regulus or Metal.
January	818,717	1,217,312	267,932	918,429
February	319,945	1,007,600	140,841	671,675
March	914,783	123,000	234,356	3,048,752
April	440,792	1,727,426	264,857	1,734,790
May	2,385,975	5,123,971	72,845	1,975,456
June	1,855,584	2,815,235	360,814	1,951,044
July	1,442,929	2,856,333	1,119,077	1,400,030
August	1,457,798	6,414,175	18,951	2,886,926
September	1,475,335	5,609,906	*Nil.*	6,201,579
October	227,329	3,518,968	36,271	3,025,609
November	425,108	2,619,132	143,118	1,812,139
December	156,148	2,615,855	60,000	2,121,889
Totals	11,920,443	35,649,113	2,719,062	27,748,318

A prominent feature of domestic production is what is called 'secondary" antimony. During 1916 the production was 4480 short

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tons, with an increase in 1917 to 4961 tons. This secondary antimony was practically all recovered from alloys, the principal materials remelted being hard lead, drosses, solder, pewter, babbitt and type metal. According to a report from the regular smelters 370 tons of antimony was recovered from lead scrap. Antimony used in the rubber, glass, enamel, paint and ceramic industries does not lend itself to treatment for recovery of the antimony. During 1917 the recovery from secondary sources was equal to about 28 per cent. of the total imports, and was approximately double the production from ores of domestic origin.

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Austria	*Nil.*	207	162	*Nil.*	*Nil.*	*Nil.*	13	.....	.....	.....	.....	.....
China(*b*)	3,829	2,316	9,356	7,937	6,643	6,986	13,531	13,032	19,645	23,357	24,727	38,539
France	3,433	3,945	3,850	5,444	4,640	4,775	5,406	6,390	.....	.....	*b)* 3802	*b)* 1730
Hungary(*a*)	1,322	841	670	695	782	892	859	1,038	.....	.....	.....	.....
Italy	537	610	345	59	*Nil.*	*Nil.*	*Nil.*	76	138	548	660	486
Japan	627	248	198	157	120	97	80	21	3,865	8,347	12,398	6,572

(*a*) Regulus. (*b*) Exports of regulus and refined metal.

Production in Foreign Countries

France.—It is said that prior to 1914 the antimony orebodies in France were becoming pretty well exhausted and that French smelters were obliged to import from China sufficient ore to keep the industry alive. Consequently, the outbreak of war found France almost entirely dependent upon outside sources of supply, but it was not long before a new company was formed to exploit large deposits of oxidized antimonial ores found in Algiers. These ores were shipped to Haute-Loire and were there smelted directly in a blast furnace. The war needs ensured the rapid development of this enterprise and during the first months of 1917 more than 300 tons of metal per month was produced. This was sufficient to cover a large part of France's military necessities. During that time the total production for France was over 600 tons monthly and about 35 per cent. of this was obtained from the treatment of native stibnite ores by the volatilization roasting process.

Bolivia.—This country was one of those which profited greatly by the antimony boom caused by the war. Between 1911 and 1914, the production never exceeded 320 tons per year, but in 1915 there was a sudden jump to 17,923 tons of ore. This increase was brought about chiefly by the demands of Great Britain. In 1916 the production reached 27,414 tons, of which 21,363 tons went to Great Britain, 3909 to the United

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States, 871 tons to France, 986 tons to Chile (mostly for re-exportation) and 10 tons to Argentine. In 1917 production was still further accelerated, but toward the end of the year Great Britain ceased to be a buyer, and it is reported that the industry is now at a standstill. The falling off in the British demand was probably due to the fact that about this time Spain began to ship large quantities of ore to Britain.

Mexico.—Judging from Department of Commerce figures for 1918, antimony mining has been conducted quite energetically in Mexico during the past year. The figures show that 1449 tons of ore and 2691 tons of metal was shipped to the United States as compared with 1600 tons of ore and 1000 tons of metal during 1917.

Japan.—In *Commerce Reports* of Feb. 19, 1919, it is stated that in 1917 Japanese production of antimony decreased by about 30 per cent. This statement bears out the contention that Japan is not and can not be a large producer of antimony, but it is not easy to reconcile it with the fact that during the same year imports from Japan to the United States were nearly double those from China. Of course, it is well known that most of the metal imported from Japan is really bought in China by the Japanese and re-exported. The figures given by the Japanese Bureau of Mines for 1917 were 6562 tons of metal and 10 tons of crude. It is estimated that the production for 1918 would be about equal to that of the previous year.

Africa.—From the *South African Mining Journal* of July 20, 1918, we learn the following with regard to the antimonite found in the gold reefs of the Murchison range. The reefs extend for some thirty miles, attaining a width, in places, of 20 feet, making workable masses of ore which have been developed to a depth of 200 feet. The ore contains from 6 to 60 per cent. antimonite and from 3 dwt. to 1 oz. of gold to the ton. It is only recently that the ore has been considered worth working and a railroad has been laid down. The range is only about 200 miles from Delagoa Bay, and a considerable quantity of hand-picked antimonite has been exported. It is hoped that attempts now being made to treat the ore locally will ultimately prove successful.

In the Steynsdorp division of the Barberton district ore amounting to 475.8 tons and valued at about $42,000 was shipped during the first six months of 1917.

Bohemia.—The *Metal Bulletin* of September 10, 1918, states that Aron Hirsch & Son of Halberstadt, Germany, were then negotiating with a Bohemian bank for the purpose of forming a company to exploit some gold-antimony ore deposits at Mileshau, in the Budweis district. This property was owned by a Paris firm before the outbreak of war, but had been idle for some time.

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China.—The leading country in the production of antimony has, during the past year, more than maintained its supremacy, as is shown by a glance at the figures of importation from China to the United States. The total imports were 27,748,318 lb., while those from China, including Hongkong, amounted to 15,335,735 lb. or just over 55 per cent. of the total. It is known that many of the smaller operators in China went out of business because of the low prices being paid for antimony, but in spite of that the output was pretty well maintained due to the extra efforts put forth by the larger companies. In fact when one considers the conditions that have existed in China, throughout the year, it would have been no surprise if the output had fallen off considerably, in which event the United States Government would have been greatly handicapped in its military program.

The Wah Chang Mining & Smelting Co., Ltd., deserves the chief credit for maintaining the exports from China when conditions were extremely hard and the prices being paid were none too attractive. There was also the political situation in China itself, always more or less uncertain, and the high rate of exchange, which always has a detrimental effect on exports from China. The Wah Chang Mining & Smelting Co., Ltd., the leading Chinese producer and consequently the world's leading producer, exported during 1918 in the neighborhood of 12,600,000 lb. of regulus and crude besides considerable quantities of oxide.

EXPORTS OF ANTIMONY REGULUS FROM SHANGHAI

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year, Tons.
1917.....	451	1653	787	850	1575	1780	1920	684	1062	459	1504	930	13,657
1918*.....	668	230	546	1392	976	2193	1923	1763	975	950	785	....	

EXPORTS OF ANTIMONY CRUDE FROM SHANGHAI

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year, Tons.
1917.....	914	878	2381	3615	4156	3899	2161	1709	569	60	300	166	20,808
1918*.....	407	117	100	.....	100	250	185	170	80	100	50	....	

*From information supplied by the Shanghai office of Wah Chang Mining & Smelting Co., Ltd.

Consumption of Antimony in the United States

Several attempts have been made to estimate the quantity of antimony being used in the United States during 1918. One American authority, figuring on the quantity of antimony available during 1917, estimates an average monthly consumption of 1450 tons, but this figure is discounted by the fact that considerable stocks were being carried both in

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warehouse and at the factories of consumers and the actual consumption was probably nearer 1200 tons a month. During 1918 the war program of the U. S. Government was greatly accelerated and its requirements, which at the beginning of the year were from 300 to 400 tons per month, had increased to around 500 tons per month by the middle of the year. This increase on the part of the Government was to some extent counterbalanced by a decrease in consumption by some manufacturers who had previously been engaged in the production of munitions for the Allied countries, and as the total imports for the year were considerably less than in 1917, it is almost certain that consumption was somewhat below that of 1917.

CONSUMPTION AND PRODUCTION OF ANTIMONY DURING 1917 AND 1918*

Material and Product.	No. of Establishments.	Output of Product (lb.).	Antimony Contents (lb.).	Output of Product (lb.).	Antimony Contents (lb.).	Per cent. of Total Antimony Consumption.	
		1917.	1917.	June, 1918.	June, 1918.	1917.	June, 1918.
Class of Product							
Babbitt metal	223	86,951,000	11,488,100	8,794,000	1,020,800	29.7	28.1
Hard lead, including pipe, traps, etc.	63	43,270,000	4,306,300	5,596,000	443,000	11.1	12.2
Soft metal alloys and solder	6	34,427,000	3,456,200	3,678,000	369,700	8.9	10.2
Type and type metal, linotype, electrotype, and stereotype	73	28,855,000	3,371,800	2,245,000	248,000	8.7	6.8
Vulcanized rubber and rubber goods	161	54,755,000	2,740,800	4,859,000	305,800	7.1	8.4
Shrapnel and other bullets	11	72,310,000	2,712,500	6,311,000	423,500	7.0	11.7
Bearing or antifriction metals not elsewhere specified	40	84,447,000	2,542,400	8,061,000	236,400	6.6	6.5
Battery plates	15	42,298,000	2,352,100	3,610,000	174,800	6.1	4.8
Enamel on metal ware	4	108,215,000	1,801,000	4,150,000	119,900	4.6	3.3
Cable coverings	9	102,517,000	1,027,500	4,182,000	42,000	2.7	1.1
Chemicals, paints and pigments	17	2,268,000	971,700	192,000	82,400	2.5	2.3
Brass, including bronze	45	28,309,000	373,000	2,716,000	28,000	1.0	0.8
White metal and alloys	10	2,460,000	276,500	177,000	18,900	0.7	0.5
Foil and collapsible tubes	5	7,280,000	207,200	504,000	11,600	0.5	0.3
Aluminium alloys	11	4,697,000	169,800	318,000	22,600	0.4	0.6
Brittania metal	23	2,663,000	159,000	154,000	8,900	0.4	0.2
Casket, carriage and other hardware and lighting fixtures	17	1,154,000	139,500	130,000	16,700	0.4	0.5
Metal packing and rings	3	754,000	105,700	66,000	9,100	0.3	0.3
Primers for explosives	7	17,780,000	82,200	302,000	9,300	0.2	0.3
Pattern metal and molds	17	602,000	41,300	70,000	4,500	0.1	0.1
Powdered antimony	3	110,000	10,800	8,000	300	(a)	(a)
Pewter	6	65,000	3,200	1,800	130	(a)	(a)
Antimony black	3	3,900	300	380	50	(a)	(a)
Other products (b)	.....	988,000	405,500	56,000	35,220	1.0	1.0
Antimonial Material used							
Antimony metal	.....	.....	17,388,300	.....	1,610,100	84.9	85.3
Antimony metal or antimonial lead	.....	.....	15,517,100	.....	1,488,100		
Antimony oxides	.....	.....	2,248,300	.....	139,700	5.8	3.9
Crude or needle antimony	.....	.....	805,200	.....	79,900	2.1	2.2
Colored sulphides of antimony	.....	.....	2,785,500	.....	313,800	7.2	8.6
Total	683	.....	38,744,400	.....	3,631,600	100.0	100.0

* From Census of War Commodities, published by Department of Commerce.
(a) Less than one-tenth of 1 per cent.
(b) Includes: Glassware, thermocouples, siphon tops, and undesignated products.

ANTIMONY CONFERENCE

No review would be complete without making reference to the conference held during the year at San Francisco for the purpose of deciding

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whether it would be advisable to encourage domestic production of antimony by levying a heavy import duty on the metal. The importance of the material for war purposes gave domestic producers the opportunity of bringing this question before a government commission and various able arguments were forthcoming in support of the increase of duty. However, most of the arguments lost sight of the main point, which is this—is it good policy to punish consumers by forcing them to pay high prices for a metal that has no extensive use except in war time and which at present can be produced in abundance at comparatively low prices? This is exactly what a high duty would mean and it is doubtful whether even a flat rate of duty of 7½ cts. per lb. on antimony would bring about the desired result. Many consumers show a decided preference for the best imported brands of antimony, and domestic producers would find that they would have to compete in quality as well as in price of the metal before they would be able to overcome established preferences and assure the success of the home industry. The strongest argument put forward in support of the protective tariff is that some day the United States might find herself involved in a war in which she would be dependent upon foreign sources of supply and that these supplies might be suddenly cut off. The answer to that argument is that no industry can be maintained on a sound basis unless it is essential to peace as well as to war, and whether we believe in the effectiveness of the League of Nations or not we certainly hope that wars will be on the decrease rather than the increase.

Antimony Market in 1918

The price of antimony throughout the year until the signing of the Armistice ruled very steady, and there were no more evidences of excitement than there would be at any ordinary time. It is true that consumption continued at a rate much above the ordinary demands of the trade, but the chief buyer was the United States Government and, although there was no official regulation of price, government buying was conducted in such a manner as to preclude the possibility of any sharp advance in prices. In addition to this prudence on the part of government departments, there was at all times an abundant supply of antimony in the country and a very keen desire on the part of holders to secure government business, and these causes combined to produce a slight downward tendency of prices.

The fluctuations in price did not amount to more than 2 cts. per lb. and were distributed over a long period. The year opened with prices at 14 cts. per lb. with a slow decline as the year advanced until in May the level reached a little over 12 cts. Then began a slow advance and in

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AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK
(In cents per pound)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1913													
Cookson's	9.94	9.47	9.28	9.13	8.88	8.79	8.54	8.38	8.37	7.60	7.62	7.50	8.73
U. S.	9.53	9.09	8.85	8.50	8.37	8.27	8.08	7.91	7.93	7.27	7.30	7.25	8.22
Ordinaries	8.97	8.25	8.18	7.98	7.79	7.64	7.55	7.39	7.37	6.49	6.45	13.90	7.52
1914													
Cookson's	7.39	7.25	7.31	7.36	7.37	7.25	7.21	17.25	11.83	14.68	17.75	16.10	10.73
U. S.	7.11	7.06	7.07	7.05	7.02	7.00	6.94	15.80	...	...	...	...	...
Ordinaries	6.13	6.10	6.05	6.01	5.84	5.83	5.64	13.80	9.94	12.06	14.45	13.31	8.76
1915													
Cookson's	17.56	20.43	27.84	32.07	Quotations ceased.								
Chinese and Japanese	15.24	17.62	20.90	23.97	34.71	36.53	35.98	32.57	28.50	30.96	37.38	39.36	29.64
1916													
Cookson's	None offered.												
Chinese and Japanese	42.26	43.77	44.71	41.35	32.20	20.40	14.55	12.62	11.57	12.44	13.65	14.39	25.33
1917													
Chinese and Japanese	17.29	29.89	32.89	34.04	25.20	19.51	15.83	15.06	14.94	14.75	13.91	15.06	20.69
1918													
Chinese and Japanese	14.28	13.82	13.09	12.54	12.85	13.06	13.20	14.00	14.15	13.32	8.77	7.92	12.58

1913–14 from *Eng. Min. Jour.* 1915–16 from *Metal Statistics.* 1917–18 from *Eng. Min. Jour.*

September the price again reached 14 cts. About this time it began to be realized that war was nearing its end and the inevitable consequence was a sharp decline to about 8 cts. The close of the year found the antimony industry, as indeed many other industries, in a very much upset and uncertain condition, because most traders were of the opinion that little profitable business could be done until business had returned to normal. At the present time it would be futile to venture any prophecy as to the future of the market, but knowing the conditions under which antimony is now being produced in the chief producing countries, one may be allowed to hope for an improvement in prices over the present entirely unprofitable limit.

Uses of Antimony and Antimony Compounds

The uses of antimony have been described in previous issues of The Mineral Industry and it is not necessary to repeat them. The extent of the various uses is well shown in the table of consumption given above.

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ARSENIC

By Allison Butts

The demand for arsenic in 1918 continued exceptionally strong.

The domestic production in 1918 was 11,323 short tons of white arsenic. This quantity is 85 per cent. greater than that produced in 1917. The value of the output in 1918 at the price fixed was $2,112,550, but the actual value was probably slightly greater, as the price was not fixed until February. There was also produced 3487 lb. of metallic arsenic, valued at $2610.

The price of white arsenic was fixed by the Food Administration in February at 9 cts. per lb., with a small advance allowed to local dealers. Just previous to this regulation the price had been 16 to 18 cts. per lb., while early in 1916 before the scarcity developed due to the war the price was 4 cts.

The United States production is by 4 companies, operating 7 plants. The two principal producers are the Anaconda Copper Mining Co. at Anaconda, Mont., and the American Smelting & Refining Co. at Denver, Colo. The latter has an output of about 120 tons per month and the former 300 tons, but the Anaconda company is constructing large additional capacity in connection with their new smoke-recovery plant. The fume, recovered in box-type Cottrell treaters, will be charged into a reverberatory furnace. The gases from the furnace will be cleaned by passing them through hot-treaters and then the arsenic fume precipitated in a cold Cottrell treater. A recovery amounting to 35 tons of white arsenic in 24 hr. is expected, which is considerably more than the present consumption in the United States and would be about equivalent to the domestic consumption of arsenic in all forms. The product of the arsenic treater runs about 92 to 95 per cent. pure and will be sold without further refining.

The demand for arsenic in 1918 was not confined to the United States; there was a scarcity in several countries, notably in England, France, and Australia, all producers themselves. Exports from the United States were negligible before the war, but last year some shipments were made to England and to South America.

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STATISTICS OF ARSENIC IN THE UNITED STATES (a)
(Short Tons)

Year.	White Arsenic.							Sulphide of Arsenic.		
	Production.		Imports.		Supply.			Imports.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
1904	36	$2,185	204	$16,899	240	$19,084	$79.50	3,196	$226,481	$70.87
1905	754	35,210	616	37,342	1,370	72,552	52.96	3,222	219,198	68.03
1906	737	63,460	167	13,436	904	76,896	85.07	3,820	336,609	88.12
1907	1,751	16[illegible],000	203	21,558	1,954	184,558	94.47	4,961	553,440	88.61
1908	1,302	99,193	168	13,263	1,470	112,456	76.46	4,796	417,137	86.97
1909	1,214	52,946	444	31,235	1,638	84,181	51.39	3,592	272,493	75.86
1910	1,497	52,305	1,010	62,590	2,507	114,895	45.83	4,128	251,716	60.97
1911	3,132	73,408	1,921	116,948	5,053	190,356	37.68	2,702	159,626	59.04
1912	3,141	190,757	3,103	200,616	6,244	391,373	62.68	3,379	246,815	73.04
1913	2,513	159,236	1,519	133,597	4,032	292,833	72.62	3,344	285,537	85.38
1914	4,670	313,147	1,594	109,121	6,244	422,268	67.42	2,040	165,266	81.03
1915	5,498	302,116	1,400	113,677	6,898	415,793	60.28	1,787	154,517	86.46
1916	5,986	555,187	1,071	107,876	7,057	663,063	93.96	1,090	124,844	114.49
1917	6,151	1,118,313	1,178	264,534	7,329	1,382,847	188.50	2,716	410,341	147.80
1918	11,323	2,112,550	1,847	441,212	13,170	2,553,762	193.90	5,651	998,011	176.61

(a) Production from U. S. Geol. Surv.; imports from Dept. of Commerce.

Arsenic in Foreign Countries

Canada.[1]—The Canadian production includes arsenious oxide, refined and crude, produced in the smelting of the arsenical silver-cobalt-nickel ores of the Cobalt district, in addition to which arsenic has been recovered at Tacoma, Wash., from the arsenical gold concentrates shipped from the Hedley gold mine at Hedley, B. C. The total production in 1918 was 2483 tons of arsenious oxide and approximately 1015 tons of arsenic in concentrates, having a total valuation of $561,128. The production in 1917 was 2656 tons of arsenious oxide and 280 tons of arsenic in concentrates, having a total value of $669,431.

The exports of arsenic in 1918 were 2672 tons valued at $393,883.

Great Britain.—The production comes from Cornwall and Devon, and in spite of the high prices ruling shows a falling off for 1918, the output being only 2225 long tons, against 2574 tons in 1917. Some years ago Cornish white arsenic sold at £8 per ton, but since the war over £150 has been obtained, with a price of £100 at the middle of 1918. Later in the year the price fell off considerably. High-grade white arsenic has been imported from Australia, Japan, Greece, and the United States during the scarcity.

Greece.—This country has recently become a regular producer of arsenic, shipping a product running over 99 per cent. As_2O_3. Statistics of the output are not available, and the country is not included in the table of world's production given below.

[1] Prelim. Rept. Min. Prod. of Canada, Dept. of Mines, 1918.

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Queensland.—There is a unique demand for large quantities of arsenic in Queensland, due to the discovery[1] that it is the only specific for the agricultural pest known as prickly-pear, which has been spreading at an alarming rate—said to be 1,000,000 acres annually—in Queensland. The State has several valuable deposits of arsenic ores, and the demand has become so urgent that the State has started the development of a mine at Jibbinbar and is erecting a plant for the treatment of the ore.

The Report of the Under Secretary for Mines for 1918 contains the following:

"The high price ruling for arsenic continued to stimulate its production in the Stanthorpe district, where the yield was nearly 199 tons, of the value of £2981, compared with only 32 tons in quantity and £580 in value for 1917. The bulk of the output was from the Beecroft mine, near Sundown, the remainder coming from the Orient leases at Carpenter's Gully. At the first-mentioned mine, where operations were continuous throughout the year, the ore is treated by screening and jigging, and the concentrates, which are estimated to contain 30 per cent. arsenic, are despatched to Bendigo, Victoria. The Orient leases, where the ore is of exceptionally good quality, were, owing to long-continued dry weather, under exemption during the latter part of the year. In the State arsenic mine at Jibbinbar, in the Stanthorpe Field, the main shaft has been sunk to 106 ft., poppet legs have been erected, and a winding plant has been installed. A second, or air, shaft has been put down to 125 ft., and a level driven over half the distance required to connect with the main shaft. An eastern cut (No. 1) has proved the lode channel 11 ft. thick between the walls, and in No. 2 cut 9 ft. thick. Both cuts carry a strong lode, 2 ft. thick, on the footwall. A concrete dam, with a capacity of 200,000 gal., has been constructed on Pine Creek, near the main shaft. A concentrating and furnace plant, with necessary buildings and other appurtenances, are now in course of construction."

Arsenic is found in most of the mineral-bearing fields of the State, but, so far as investigations have shown, it is principally found at Jibbinbar near Stanthorpe, and at Calliope near Gladstone. In both localities deposits are known which are of large extent and could be worked very effectively for the mining of mispickel, the natural arsenical sulphide of iron. In northern Queensland extensive lodes of arsenical ores are said to exist, but up to the present little is known officially as to their extent or value.[2]

A maximum price of £60 per ton for white arsenic within Australia has been fixed by the Government.

Rhodesia.[3]—The manufacture of white arsenic on a commercial scale was brought to a successful stage in Rhodesia early in 1918, the report of the Munitions and Resources Committee states. One unit of a plant is at present in operation, the output from which is about 14 tons per

[1] MINERAL INDUSTRY, 26, 46 (1917).
[2] *Queens. Govt. Min. Jour.*, June, 1918.
[3] *Board of Trade Journal*, London, through *Comm. Rept.*, Nov. 16, 1918.

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month. The plant is now being increased, and it is hoped to produce about 100 tons per month before the end of 1918. The product assays about 99 per cent. As_2O_3, and this grade is obtained from the ore in one operation. For the time being all the arsenic produced is shipped to the Union of South Africa for the manufacturing of arsenite of soda, but it is the intention of the syndicate now carrying on the work to turn out sheep-dips itself at a later date. Experiments in the recovery of arsenic as a by-product have been conducted. A considerable amount of attention was devoted during 1917 to prospecting for arsenical ores, and bodies of mispickel ore are now known to exist within reasonable distance of the railway line which could supply South African requirements for arsenical compounds for many years. White arsenic recovered as a by-product in gold mining would doubtless find a ready sale if the manufacture of dips and of arsenite of soda is begun, but the regular source, the committee states, would necessarily be from high-grade mispickel ores such as are known to be available in the country.

The arsenic production of Southern Rhodesia for 1918 was 114 long tons; the ore treated was 435 tons.

Union of South Africa.[1]—Within the past 6 months a promising start has been made to produce white arsenic locally. The output for the first 4 months of 1918, amounting to 6185 tons, valued at £619, came from the Stavoren Tin Mine, where massive arsenopyrite occurs, together with cassiterite, scheelite, copper pyrite, and other minerals. A plant for the production of white arsenic is also being erected at the Consort Mine in the Barberton district. Here arsenopyrite is associated with gold. As some £80,000 worth of arsenite of soda is annually consumed in the Union, the prospects of the industry appear very hopeful.

WORLD'S PRODUCTION OF ARSENIC
(In Metric Tons)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1903	233	2,768	50	6	698	1,088	916	554	6,658
1904	66	2,829	80	4	1,370	400	992	452	3,117
1905	*Nil.*	2,535	.....	8	1,562	1,140	1,552	701	3,627
1906	*Nil.*	3,052	.....	5	1,322	1,114	1,625	754	6,534
1907	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908	649	2,822	451	20	1,655	2,004	2,007	1,301	2,381
1909	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912	1,858	4,869	*Nil.*	.....	1,006	(c)	2,228	2,855	81,890
1913	1,538	5,008	*Nil.*	.....	925	.....	1,716	2,158	70,613
1914	1,576	.....	*Nil.*	.....	960	.....	2,007	4,238	.....
1915	2,174	.....	*Nil.*	15	.....	.....	2,536	4,990	.....
1916	1,983	.....	*Nil.*	(c)	.....	.....	2,575	5,430	.....
1917	2,663	.....	*Nil.*	(c)	.....	.....	2,616	5,580	.....
1918	3,173						2,261	10,272	.....

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore.

[1] *So. Afr. Min. Eng. Jour.*, Feb. 22, 1919.

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Technology and Uses

An extensive report on arsenic has been prepared for the Queensland Geological Survey.[1] In addition to the local deposits, it takes up the sources, mineralogy, geological occurrence and origin, extraction and refining, and uses of arsenic. Regarding the latter it contains the following:

"The chief industrial uses of arsenic are for glass-making and the preparation of insecticides, sprays, dips, and medicines. In the manufacture of glass arsenic, in the form of white arsenic-glass (a hyaline variety of white arsenic), is added to the molten glass, to which it imparts a clear crystal lustre and increased transparency. It is supposed that the arsenic forms arsenides with iron and manganese present in the molten glass, and these impurities settle to the bottom of the pot, leaving the glass pure and clear. Some of the arsenic added, if an excess is used, enters into the composition of the glass, and gives a pearly lustre to the product. Arsenical insecticides are extensively used as sprays in agriculture and horticulture. Paris green and lead arsenate are extensively used as insect poisons. Orpiment is used to some extent in textile dyeing. The use of green arsenical dyes and paints for wall paint and wall-paper has in latter years fallen into disuse on account of the poisonous nature of the dust from such materials. Metallic arsenic is largely used for hardening lead in shot making. It is also replacing antimony in the manufacture of chilled shot. Crude arsenic trioxide (gray arsenic) has long been utilized for killing weeds along railway tracks, and it has also been successfully used for spraying noxious weeds. Water hyacinths in Gatun Lake, Panama, were poisoned by spraying with a mixture made by boiling 25 lb. of arsenic, 25 lb. of soda, and 25 gal. of water for one hour and diluting with 425 gal. of water.

"Scattered prickly-pear plants are best destroyed by injecting the poison, for which purpose a mixture is made of 15 lb. of common salt, 10 lb. of white arsenic, and 4 lb. of caustic soda. A teaspoonful of the powder is placed in a longitudinal incision in one of the lower leaves. The same mixture can also be mixed with water and diluted to 8 gal., in which case a wineglass full of the concentrated solution is injected per plant. By diluting this same concentrated solution to 100 gal. a suitable solution for spraying dense prickly-pear can be made. The arsenic poison destroys the corneal tissue of the pear and the plant dies, after which it can be burnt. It has also been discovered that by gassing dense prickly-pear with arsenious chloride gas the same result is achieved, and with less trouble. The most important industrial application of arsenic in Australia has been for the manufacture of cattle dips, for which purpose arsenite of soda is used. These dips are utilized to kill the cattle-tick, sheep-lice, and other vermin in the coats of animals, and also to moderate the mischief done by the sheep-maggot fly."

In melting glass, white arsenic thrown in the fused batch immediately sinks to the bottom and there vaporizes rapidly, causing a bubbling up of the bath with a purifying and an homogenizing effect. Very little arsenic remains in the glass. White arsenic is also used as a decolorizing agent for glass; it oxidizes the carbon and sulphur compounds which give a yellowish color to the glass. It also diminishes or destroys colorations due to metallic oxides, and has the property of giving brilliancy and augmenting the resistance of the glass.[2]

[1] "Arsenic and Its Occurrences in South Queensland." Dr. H. I. Jensen, *Queens. Govt. Min. Jour.*, Oct. 15, Nov. 15, 1918.

[2] *Chem. Ztg.*, **42**, 14 (1918), through *Chem. Abstr.*, **12**, 1342.

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ASBESTOS

Arizona was the largest and most important producer of asbestos in the United States in 1918, and it is reported that three companies were the chief producers, working in the Ash Creek district, north of Globe. A few prospectors worked their claims, but their properties were not opened up sufficiently to judge further possibilities. In Maryland, residual deposits of amphibole asbestos were worked to some extent, and this product supplied the demand for asbestos in filters, which formerly had been secured by import supply. In California, the Sierra Asbestos Co., near Nevada City, operated a mine and a 100-ton mill, shipping the product to the John D. Hoff Asbestos Co., of San Francisco, general agents for the distribution of this material. The process of fiberizing which that company utilizes is new and efficient, and consists of a jaw crusher, and a 20-stamp mill of 1200-lb. stamps, crushing to ⅛ mesh. The material is then conveyed to a double shaking screen, and the fiber is taken off the screen by means of suction blowers. The screenings go to a Canadian fiberizer, and, by suction, the fiber is carried to separators and a revolving screen for grading into No. 1, No. 2, and No. 3 mill grade, free from sand. The mine is operated as a quarry, tunnel, and gloryhole system, the ore being taken to the mill by a 1000-ft. aerial tramway. The entire plant is operated by water power.

Several other deposits of chrysotile asbestos have been found in California and are being prospected. Amphibole asbestos in California consists of bunches and lenses of ore, but little of it was produced in 1918.[1] The production in 1918 amounted to 229 tons, as compared with 136 tons in 1917, mostly of the chrysotile variety.

The total domestic production in 1918 amounted to only 800 tons, as compared with 1683 tons in 1917. This is a reduction of almost 50 per cent. in quantity and of almost 75 per cent. in value.

With such a small domestic production, and such a great demand to be supplied by imported material, it is somewhat surprising to find exports from this country amounting to $2,493,325 in manufactured material, besides 697 short tons of domestic ore and unmanufactured material, valued at $51,053, and 266 short tons of foreign ore and unmanufactured material, valued at $29,018.

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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ASBESTOS IMPORTED INTO THE UNITED STATES
(Figures furnished by Bureau of Foreign and Domestic Commerce, Department of Commerce)

Country.	1917.			1918.		
	Unmanufactured.		Manufactured (Value).	Unmanufactured.		Manufactured (Value).
	Quantity (Short Tons).	Value.		Quantity (Short Tons).	Value.	
British South Africa	1,791	$168,204	.....			
Canada	131,525	4,148,217	$13,495			
Colombia	.....	.....	.....			
England	296	65,651	40,449			
France	.....	.....	8,428			
Germany	.....	.....	.....			
Japan	.....	.....	.....			
Italy	.....	.....	2,721			
Portuguese Africa	496	139,100	.....			
Scotland	.....	.....	3			
Total	134,108	$4,521,172	$65,096	137,396	$6,337,585	$27,476

Asbestos in Foreign Countries

Canada.—The main feature of the Canadian asbestos-mining industry in 1918 was the introduction of the gloryhole method and hoisting by shaft at one of the large mines, that of the Jacobs Asbestos Co., at Thetford, to replace the open-pit method; and the elimination at the Jeffery mine of cable-derricks for hoisting the rock, which is now loaded at the bottom of the open pit by steam shovels on cars which are hauled to the mill in trains. The Quebec Asbestos Co., at East Broughton, has restored its mill after the fire of last spring and is treating about 350 tons daily. The Frasier mine of the Asbestos Corporation completed a mill, and the Montreal property, under option to a Boston syndicate, has begun construction of a mill, which will be completed in the spring. The Regina Asbestos Co. and the Berlin Asbestos Co., at Robertson Station, and the Imperial Chrome and Asbestos Co., at Black Lake, have shown considerable activity. The new milling plant of the Windsor Asbestos Co., at Coleraine Station, was recently burnt to the ground. During 1918, 18 mines were in operation in the Quebec district. The question of cheap handling of the asbestos rock is a vital one, as about 2¾ million tons are hoisted yearly at the present rate of production.

Both the tonnage and the value show marked increase as compared with 1917, although the amount of rock mined was less, 2,445,745 tons in 1918, as compared with 2,634,410 tons in 1917. The value of the asbestos recovered from the average ton of rock was $4.06 in 1918, $3.08 in 1917, and $2.13 in 1916.

As the grading of asbestos has not been standardized, it is difficult to compare prices, except as between the same grades of the same producer. This is aggravated by the fact that the grades are numerous,

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passing gradually from one to the other, and they vary in value from $5 a ton for low-grade mill stock, very short fiber, to $1500 a ton for selected "Crude No. 1" of fiber of over one inch in length. Average prices for "paper stock" during the last six years have been: 1913, $28 per ton; 1914, $27; 1915, $31.50; 1916, $39; 1917, $53; and 1918, $60 per ton. By far the greater part of the Quebec asbestos is exported to the United States. Next in importance as a consumer of asbestos is England, followed by Japan, France, Italy, and other countries.

In addition to steady production at the mines which were in operation during 1917, several which have been idle for some years were reopened, including the Berlin mine at Rumpelville, the Regent mine at Robertson and the Eastern Townships mine at East Broughton. The Dominion Asbestos Spinning Co. has started at East Broughton, Quebec, a plant for the manufacture of asbestos yarn, carded asbestos and sheet packings. Asbestos cloth, brake linings and packings will be manufactured when the necessary machinery can be obtained.[2]

There was a falling off in 1918 of 1955 tons in the output and 1691.8 tons in the sales of crude asbestos, but an increase in average price of crude, from $510.47 per ton in 1917 to $671.35 in 1918. The shipments of mill stock were increased in 1918 by 7660 tons and the average price was increased from $34.08 in 1917 to $46.87 in 1918.

The total value of the shipments of asbestos and asbestic in 1918 was $8,970,977 as against $7,230,383 in 1917.

The average number of men employed in mining was 1674 and in milling 1400, or a total of 3074, and the total wages paid were $2,871,643. The tonnage of rock mined and quarried was 2,462,381 and the tonnage milled was 2,185,572.

OUTPUT, SALES, AND STOCK OF ASBESTOS IN CANADA

	Output.	Sales.			Stocks on Hand December 31.		
	Tons.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
1918.							
Crude	4,313	3,691.6	$2,478,363	$671.35	1,685.5	$1,109,402	$658.20
Mill stock	139,143	137,770.0	6,458,442	46.87	12,560.0	941,612	74.97
	143,456	141,461.6	8,936,805	63.07	14,245.5	2,051,014	143.98
Asbestic	.....	16,734	33,974	2.03			
1917.							
Crude	6,268	5,383.4	2,748,071	510.47	1,322.6	738,195	558.14
Mill stock	135,475	130,119.0	4,435,028	34.08	11,917.0	477,289	40.05
	141,743	135,502.4	7,183,099	53.01	13,239.6	1,215,484	91.81
Asbestic	.....	18,279.0	47,284	2.59			

Exports of asbestos during 1918 were 119,454 tons valued at $7,786,710, or an average of $65.19 per ton, and of asbestic sand and waste,

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

[2] *Can. Min. Jour.*, July 1, 1918.

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22,144 tons valued at $228,059, or an average of $12.99 per ton. There was also an export of manufactures of asbestos valued at $40,763.

The exports in 1917 were: asbestos, 93,932 tons valued at $4,903,326; asbestic sand and waste, 52,088 tons, valued at $430,956; manufactures of asbestos, valued at $55,666.

The imports of asbestos and manufactures of asbestos in 1918 were valued at $604,703, as compared with imports of 1917 valued at $537,431.[1]

South Africa.—Two types of asbestos are found in South Africa. Crocidolite or blue asbestos is produced in the Griqualand West district of Cape Colony, while chrysotile or serpentine asbestos is found in the Transvaal and Rhodesia. Rhodesian white asbestos is of excellent quality, and competes with Canadian asbestos. The asbestos exported from the Union of South Africa is mainly derived from the Kuruman, Hay and Prieska districts of Cape Colony. A small quantity has been produced in Dundee district in Natal.

The production of chrysotile asbestos, which first received attention in 1907, has now grown to considerable proportions, and promises to increase even more as time goes on. The following table shows the rapid expansion of the output of asbestos in Rhodesia:

Year.	Long Tons.	Value.
1913	290	£5,224
1914	487	8,612
1915	2,010	32,190
1916	6,157	99,059
1917	9,562	189,890
1918	8,574	.....

Most of the asbestos from Rhodesia comes from Mashaba, in Victoria district, where two mines are firmly established. It is nearly all shipped from Beira, and appears in the import trade statistics of the United Kingdom as derived from Portuguese East Africa. The demand for Rhodesian asbestos is good, prices have increased, and the industry shows every sign of further progress.[2]

A new supply of asbestos has been found in South Africa in the Asbestos Mountains, in the lower Griquatown beds. The deposits here have been developed as far north as the Bechuanaland Protectorate. The work is carried on by the aid of Kafir labor, and the fiber produced averages 25 per cent. of 1 in. or over.

In the exploitation of crocidolite the Union of South Africa has a practical monopoly, since Western Australia so far only contributes a small quantity. The Cape Asbestos Co., established since 1893, has had a long uphill fight to obtain for crocidolite the recognition it deserves, and the keen competition in the world's market led to the establishment

[1] Prelim. Rept. Min. Prod. of Canada, 1918, Dept. of Mines.
[2] *So. Afr. Min. Jour.*

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of their own factories in England, Hamburg, and Turin, with a sister company in France. They are the largest manufacturing concerns for articles derived from crocidolite, and the great bulk of the Cape output is absorbed by them, largely from their own mines, but also by purchase from other workings. Thus only a proportion of the combined yield from the Cape fiber has been able to compete in the open market.

The trading of the Cape Asbestos Company expanded so much last year that the factory at Barking had to be extended and additional plant installed. The operations of the associated concerns in Italy and France were also on a bigger scale, and but for exchange fluctuations the return from this source would have risen much higher than it did.

Russia.—It is only a few years since Russia ranked second as a producer of asbestos. Due to the present disorganized internal conditions in Russia, no statistics of recent production are available. The production previous to the war was as follows:

PRODUCTION OF ASBESTOS IN RUSSIA, 1905–1916

Year.	Short Tons.
1905	8,010
1906	10,143
1907	10,451
1908	13,130
1909	16,584
1910	13,467
1911	17,423
1912	18,818
1913	19,284
1914	17,297
1915	10,780 (Estimated)
1916	9,030 (Estimated)

The principal deposits are on the eastern slopes of the Urals, in the regions of Perm and Ekaterinburg and in Siberia in Irkutsk and Yenisei.

Australia.[1]—The deposits which have been discovered in Queensland are identical in character with those of Canada, and while they are not all that might be desired in the way of a high-grade asbestos, nevertheless there are possibilities of such discoveries being made about Kilkivan, Cawarral, Marlborough, and Bowen, where the mineral has been found and worked to some extent and prospecting operations in some of the places are now in progress. The product of the mines about Cawarral and Marlborough are in demand just now for the manufacture of floorings and wall-lining, and if sufficient can be produced and the prices are moderate there is a probability that it will be used extensively in place of wood and earthenware tiles in the better class of house decoration.

With the prevailing prices of asbestos fiber, the mining of deposits should pay, and, if an industry could be established in Queensland at the present time, there would be no question about its permanence when trade conditions after the war became normal.

[1] *Queens. Govt. Min. Jour.*, June, 1918.

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Properties and Uses

The principal properties of asbestos valued in the industry are: tensile strength, flexibility, fineness of fiber, incombustibility, length of fiber, acid and alkali resisting capacities, sea-water resisting capacity, elasticity, low conductivity for heat and electricity, and color. The above order is approximately that of relative importance, though, in consequence of the many and increasing varieties of uses to which the fiber is now put, this order varies for different classes of manufactured articles; no doubt flexibility and tensile strength are of prime necessity for many articles, while length of fibre is of exceptional importance where yarn has first to be spun. In still other cases special stress is laid on acid and sea-water resisting properties or on heat insulating capacity, *e.g.*, in the manufacture of flexible boiler covering and other uses in mercantile or naval marines, whereas color is of less importance, provided other desiderata are satisfied. For these reasons not every fiber requires all the above properties to be present in the same degree for commercial purposes. Moreover, the different varieties show a good deal of variation in some of their characters, and this holds good even for an asbestos from one fiber area. Other things being equal, that variety will be the most valuable one which combines the greatest number of the most highly prized properties, each in the required degree. Given a fiber of suitable quality, many other industrial factors have to be considered in its profitable disposal in the world's markets; these include questions of labor supply, transport to railhead, shipping costs, etc., and last but not least, the more or less keen competition with other sources of supply. The discussion of these lies outside the scope of the present pages.

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ASPHALT

Domestic Output[1]

The quantity of native bitumens, pyrobitumens, ozokerite, and bituminous rock produced and sold at mines and quarries in the United States in 1917 was 80,904 short tons. This quantity was less by 17,573 tons, or 18 per cent., than the output of corresponding materials in 1916.

The 1918 production showed a still further decline of 20,870 tons, to 60,034.

The average price received for this material at the sources of production was $13.00 a ton and the market value of the entire production was $780,808, a gain of $3.90 a ton in average unit price and of $44,884, or 6 per cent., in gross market value, compared with 1917. At the mines gilsonite sold in 1917 for an average of $14.43 a ton, elaterite for $88.68 a ton, grahamite for $8 a ton, bituminous sandstone for $3.31 a ton, and bituminous limestone for $2 a ton.

The past two years has shown a material gain in the output of gilsonite, which is ascribed to several factors, including the increased demand for marine paints and protective coatings for steel work, of which that mineral forms the base, the increasing demand for automobile tires and other rubber products, in which gilsonite is used as a filler, and presumably to a slight extent to increased utilization of gilsonite fluxed with petroleum in the manufacture of paving cements. The decreased output of elaterite and grahamite was undoubtedly due to the costs of mining and marketing these materials and to the strength of the market competition with certain grades of oil asphalt.

The table following shows the combined output of all forms of natural asphalt entering the markets from mines and quarries in the United States since 1885.

Manufactured Asphalt.—The quantity of manufactured asphalt produced and sold in the United States in 1918 was 1,177,819 short tons, a loss of 169,623 tons, or about 13 per cent. under the output in 1917. The average price received at the refineries for this material was $15.08 a ton and the gross market value was $17,759,224, a gain of $3.82 in average unit price and of $2,582,720, or 17 per cent., in value, compared

[1] Abstracted mainly from *Min. Res. of the U. S.*, U. S. Geol. Surv.

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MARKETED PRODUCTION OF NATURAL ASPHALT AND BITUMINOUS ROCK
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1885	3,000	10,500	1902	84,632	$461,799
1886	3,500	14,000	1903	55,068	483,282
1887	4,000	16,000	1904	64,167	420,701
1888	50,450	187,500	1905	62,898	305,242
1889	51,735	171,537	1906	73,062	674,934
1890	40,841	190,416	1907	85,913	928,381
1891	45,054	242,264	1908	78,565	517,485
1892	87,680	445,375	1909	99,061	572,846
1893	47,779	372,232	1910	98,893	854,234
1894	60,570	353,400	1911	87,074	817,250
1895	68,163	348,281	1912	95,166	865,225
1896	80,503	577,563	1913	92,604	750,713
1897	75,945	664,632	1914	79,888	642,123
1898	76,337	675,649	1915	75,751	526,490
1899	75,085	533,904	1916	98,477	923,281
1900	54,389	415,958	1917	80,904	735,924
1901	63,134	555,335	1918	60,034	780,808

NATURAL ASPHALT SOLD AT MINES, BY STATES
(In short tons)

State.	1915.		1916.		1917.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
California	17,794	$61,485	18,135	$45,102	6,009	$19,447
Kentucky	(a) 19,311	(a) 65,352	(a) 37,777	(a) 122,984	(a) 33,910	(a) 112,808
Oklahoma	16,907	118,351	15,431	112,555	5,793	34,344
Texas	(b)	(b)	(b)	(b)	(b)	(b)
Utah	21,739	281,302	(c) 27,134	(c) 642,640	35,192	569,325
Total	75,751	526,490	98,477	923,281	80,904	735,924

(a) Includes Texas. (b) Included in Kentucky. (c) Includes Colorado.

PRODUCTION OF ASPHALT BY VARIETIES
(In short tons)

Variety.	1916.		1917.		1918.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock	63,172	$197,286	41,919	$136,255	25,346	$ 92,238
Wurtzilite (elaterite)			34,349	495,489	(b)	(b)
Gilsonite	26,870	629,640			30,848	606,639
Grahamite	8,431	92,555	4,618	103,180	3,803	36,532
Maltha						
Ozokerite	4	3,800	18	1,000	37	905
Total	98,477	923,281	80,904	735,924	60,034	780,808
Manufactured or oil asphalt (a)	688,334	6,178,851	701,809	7,734,691	527,575	7,435,204
Total	786,811	7,102,132	782,713	8,470,615	587,609	8,216,012

(a) This item includes material derived from petroleum of domestic origin only.
(b) Included with grahamite.

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with 1917. The foregoing totals include 616,547 tons of solid and semi-solid products, valued at $10,346,963, an average of $16.77 a ton, and 561,272 tons of liquid products, valued at $7,412,261, an average of $13.20 a ton.

The number of plants supplying the output of manufactured asphalt in the United States in 1917 was 40, of which 27 used exclusively petroleum from domestic sources, 9 used exclusively petroleum from Mexican sources, and 4 used petroleum from both sources.

The total sales in 1918 of manufactured asphalt derived from domestic petroleum amounted to 527,575 short tons, a loss of 174,234 short tons, or 25 per cent. under sales in 1917. The average price obtained for this material was $13.90 a ton and the market value of the entire output was $7,435,204, a gain of $2.88 in average sale price but a loss of $299,487, or 4 per cent., in total market value, compared with 1917. Included in the totals on manufactured asphalt and derived from petroleum of domestic origin are 278,166 tons of solid and semisolid products utilized mainly in the paving and roofing industries, valued at $4,371,742, an average of $15.71 a ton, and 249,409 tons of liquid products including road oils, flux, and asphaltic paints, valued at $3,063,462, an average of $12.28 a ton. Compared with the price in 1917, the average market price per ton in 1918 of the solid and semisolid products derived from domestic petroleum was $3.45 higher and that of the liquid products was $2.34 higher.

The total sales in 1918 of manufactured asphalt derived from petroleum imported from Mexico amounted to 650,244 short tons, a gain of 4631 tons, or about 1 per cent., over sales in 1917. The average price received for this material f.o.b. the refineries was $15.85 a ton and the gross market value of the material sold was $10,324,020, a gain of $4.32 in average sale price per ton and of $2,882,207, or nearly 39 per cent., in gross market value, compared with 1917.

DOMESTIC ASPHALT EXPORTED FROM THE UNITED STATES (a)

Year.	Unmanufactured.		Manufactures, Value.	Total Value
	Quantity Short Tons.	Value.		
1913	65,576	$1,267,625	$411,786	$1,679,411
1914	41,716	845,838	401,182	1,247,020
1915	42,787	735,952	438,685	1,174,637
1916	40,816	759,769	494,895	1,254,664
1917	30,107	586,673	586,055	1,172,728
1918	22,509	581,466	577,936	1,169,402

(a) U. S. Geol. Surv.

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ASPHALT IMPORTED FOR CONSUMPTION INTO THE UNITED STATES
(In short tons)

Year.	Crude.		Dried or Advanced.		Bituminous Limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1910	162,435	$588,206	20,180	$178,704	3,696	$ 9,301	186,311	(a) $785,963
1911	167,681	572,198	20,461	184,954	8,180	23,468	196,322	789,236
1912	193,645	726,345	20,707	177,992	3,976	15,808	218,328	921,145
1913	(b) 207,033	738,452	(c) 14,750	133,336	6,395	38,823	228,178	910,611
1914	137,352	664,558	*Nil.*	.....	1,705	11,060	139,057	675,618
1915	123,426	680,537	*Nil.*	.....	*Nil.*	.....	123,436	680,357
1916	131,616	733,307	*Nil.*	.....	295	1,795	131,911	735,102
1917	167,440	978,640	*Nil.*	.....	369	15,028	167,809	993,668
1918	114,686	624,967	*Nil.*	.....	67	13,853	114,753	638,820

(a) Imports for 1910 include $9752 of manufactures. (b) Includes dried or advanced asphalt for last 3 months of 1913. (c) Last 3 months of 1913 included in crude asphalt.

ASPHALT IMPORTED INTO THE UNITED STATES DURING THE FISCAL YEARS ENDING JUNE 30, BY COUNTRIES
(In long tons)

Imported from	1916.		1917.		1918.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:						
France	.....	.....	.....	.....	.....	.....
Germany	.....	.....	.....	.....	.....	.....
Italy	.....	.....	.....	.....	.....	.....
Switzerland	195	$1,197	100	$598	.....	.....
United Kingdom	763	8,768	363	3,666	1,701	$10,412
North America:						
Canada	119	1,789	95	1,742	166	2,995
Mexico	18	399	609	11,210	12,419	151,868
West Indies:						
British	95,923	511,375	105,301	592,815	74,918	433,087
Cuba	570	13,409	4,244	32,846	177	5,868
South America:						
Colombia	.....	.....	53	1,535	67	3,736
Venezuela	32,645	165,190	51,136	258,205	50,451	255,510
Asia:						
Turkey	.....	.....	.....	.....	.....	.....
Oceania	1	10	.....	.....	.....	.....
Total	130,234	702,137	161,901	902,716	139,899	863,476

MINERAL WAX IMPORTED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Quantity, Pounds.	Declared Value.	
		Total.	Price per Pound.
1913	7,141,514	$549,992	$0.077
1914	8,191,529	498,695	0.061
1915	2,845,304	214,195	0.075
1916	3,047,834	200,377	0.066
1917	899,405	90,510	0.101
1918	1,809,459	147,805	0.082

(a) U. S. Bureau of Foreign and Domestic Commerce.

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Foreign Sources

While the United States produces enormous quantities of manufactured, or oil asphalt, its production of natural asphalt is comparatively small, and it must depend on imported material for a large portion of its supplies. Chief among these foreign sources are Trinidad and Venezuela.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK (a)
(In metric tons)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (c)	Spain.	Trinidad. (b)	United States. (e)	Total.
1908...	41,000	89,009	4,818	34,761	9,231	136,583	37,389	352,791
1909...	44,800	77,537	5,054	39,165	6,582	146,013	39,640	358,791
1910...	38,500	81,208	4,994	41,705	8,473	161,587	31,159	367,626
1911...	38,000	81,902	3,861	50,179	8,495	163,080	40,307	380,824
1912...	31,535	96,112	4,460	52,707	5,387	176,077	37,570	403,888
1913...	30,892	.....	3,024	56,750	5,582	208,164	31,810	.....
1914...	.....	.....	.....	33,752	5,765	147,942	26,147	.....
1915...	.....	.....	.....	25,201	4,521	138,210	28,506	.....
1916...	.....	.....	.....	16,662	7,136	133,204	32,028	.....
1917...	.....	.....	.....	13,608	.....	132,742	35,367	.....

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1908.....	3,695	171,000	72,972	134,163	12,373	33,901	428,104
1909	2,975	169,000	(d)70,000	111,067	5,284	50,243	408,569
1910.....	1,066	170,000	(d)70,000	162,212	7,795	58,581	469,654
1911.....	1,740	169,697	(d)60,000	188,133	6,500	38,704	464,774
1912.....	4,234	312,000	(d)50,000	181,397	.....	49,691	597,322
1913	3,026	324,610	45,860	171,097	4,638	(f)52,220	601,451
1914	.....	.....	.....	119,853	.....	44,257	.....
1915.....	.....	.....	.....	47,650	.....	40,210	.....
1916.....	.....	.....	.....	16,829	.....	57,311	.....
1917.....	.....	.....	.....	8,645	.....	38,028	.....

(a) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (b) Exports. (c) Including mastic and bitumen. (d) Estimated. (e) Previously the U. S. statistics included oil asphalt. This is now omitted, leaving only the natural asphalt. (f) Includes some maltha.

Trinidad.—The asphalt lake of Trinidad is situated at Brighton, 12 miles west of San Fernando, 27 miles south of Port of Spain, and about half a mile from the Gulf of Paria. The lake itself is a flat area of approximately 120 acres, forming a basin surrounded by a low hill. The original elevation of the lake surface was 137½ ft. above sea level, but mining operations had lowered this elevation to about 130 ft. in 1918. The asphalt is dug by hand by laborers using a mattock which, at each stroke, lifts the asphalt out in single chunks weighing usually 60 pounds. The laborers carry these large blocks upon their heads to the cars in which they are hauled away.

Crude asphalt as it occurs in the lake is of a very uniform composi-

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tion, as has been determined by a large number of analyses. The composition is approximately 30 per cent. moisture, 30 per cent. mineral matter, and 60 per cent. asphalt in a very intimate, uniform emulsion, in which a large portion of the material is in a colloidal condition. During the process of heating or drying the moisture is removed by evaporation, but the mineral matter and asphalt remain in their same uniform proportions, which is one of the important properties peculiar to the Trinidad Lake asphalt and not common to other mechanical mixtures of asphalt and mineral matter. In appearance asphalt when dried changes from a dull, black, spongy substance to a hard, brittle, jet black, shiny product.

From the lake there are two systems of tramway. One is operated by an endless cable, which takes the cars to a terminal station, where the buckets of asphalt are transferred to an overhead cable tramway, conveyed to the loading jetty, a distance of nearly a mile, there dumped into the holds of the steamers, and shipped to foreign markets as crude Trinidad Lake asphalt. The second system carries the asphalt in cars of approximately 1-ton capacity up an incline to the drying plant, where they dump direct into drying stills. In these the moisture is driven off by means of steam coils, and after two days' heating the asphalt is drawn off in a molten condition from the bottom of the drying stills, poured into barrels, and placed in the storage shed until ready for shipment. Then the barrels are rolled from the shed to carriers on the overhead tramway, conveyed to the loading jetty and lowered into the hold of the steamer.

The holes dug in mining the asphalt soon fill themselves to the same level as the large flat area of asphalt forming the lake; in this way digging is repeatedly done in the same places. The lake is in constant, but slow and powerful, movement, and material left upon the surface frequently shifts its position and finally subsides.

The lake has always presented great difficulties in efforts to ascertain its depth through boring operations, as the constant movement of the asphalt tends to break or bend pipes or boring appliances driven into the lake at any considerable depth. Some borings, however, recently made under the direction of the chief geologist of the New Trinidad Lake Asphalt Co., which has the concession from the Trinidad Government for mining asphalt from the lake, have reached a depth of 150 ft., the greatest depth yet obtained. The previous record was 135 ft., reached in 1893. On both occasions the asphalt was found to have the same uniform character as in borings higher up and in other parts of the lake.

The record borings made in 1893 were accomplished by driving down a 2-in. pipe and washing the material out of the pipe by means of

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a jet with a steel bit on the bottom of it. At the depth of 135 ft. the pipe became so crooked, due to the movement of the asphalt, that further progress was impossible.

In the borings which have just been made, a core of asphalt was taken by driving a small pipe into the pitch and then withdrawing it with its contained core of pitch. Following this, a pipe of 2-in. diameter was driven to the lowest depth to which the core was taken and the material, forced into it by driving, was removed by means of a water jet and bit. Another core was taken below the 2-in. pipe in the untouched pipe. The deepest of these borings was taken at the center of the pitch lake and the asphalt was found to be of uniform character throughout. After completion, this hole was observed to have shifted at the surface 25 ft. in 6 weeks; a survey showed the movement to exist as deep as 100 ft., and there was a suggestion that the direction was reversed at a depth of between 25 and 50 feet. The other borings, not at the center of the lake, shifted to a lesser extent.[1]

TOTAL EXPORTS OF ASPHALT FROM TRINIDAD, 1911–1917 (a)
(In long tons)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1911	103,590	8,040	111,630	67,105	.....	67,105	983	.....	983	179,718
1912	95,111	8,600	103,711	85,299	.....	85,299	486	.....	486	189,496
1913	123,873	1,400	125,273	104,153	.....	104,153	605	.....	605	230,031
1914	67,357	2,950	70,307	75,297	.....	75,297	.....	.....	.....	145,604
1915	117,001	1,250	119,251	18,025	.....	18,025	.....	.....	.....	136,026
1916	117,719	.....	117,719	13,380	.....	13,380	.....	.....	.....	131,099
1917	119,149	.....	119,149	11,496	.....	11,496	.....	.....	.....	130,645

(a) U. S. Geol. Surv., through courtesy of Barber Asphalt Paving Co.

Venezuela.—Statistics of asphalt exported from Venezuela in 1916 and 1917 seemed to indicate for the asphalt industry of that country a gradual return to pre-war conditions. Exports for several years past are as follows:[2]

	Quantity, Short Tons.	Value.
1906	24,783	$98,250
1907	42,153	167,938
1908	35,324	141,912
1909	41,767	180,061
1910	35,717	151,000
1911	56,183	238,000
1912	73,780	312,000
1913	93,884	400,000
1914	49,941	.....
1915	31,949	.....
1916	49,176	.....
1917	54,410	.....

[1] *Comm. Rept.*, June 3, 1919.
[2] U. S. Geol. Surv.

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Preliminary figures for production in 1918, however, show the lowest production for 10 years.

ASPHALT PRODUCTION IN VENEZUELA FOR 1917 AND 1918

	1917		1918	
	Tons.	Value.	Tons.	Value.
New York & Bermudez Co.	52,991	$1,059,820	28,200	$564,000
The South American Co.	68	1,360	50	1,000
Riopauji Mines	1,008	20,160	.....	.....
Totals	54,067	$1,081,340	28,250	$565,000

The value placed on asphalt at the points of production is $20 per ton

The Caribbean Petroleum Co. and the New York & Bermudez Co. are under the same management and are reported to be controlled by the Standard Oil Co. They form a monopoly in both products, so far as production in this country is concerned.

The asphalt concessions cover an area of 17,250 acres and are nine in number, including Guanoco Lake, that is controlled by the New York & Bermudez Co., and has an area of 12,000 acres, the rest of the lands being in the leases of the South American Co.[1]

Italy.[2]—Until about three years ago the exploitation of asphalt in Italy was in the hands of a single company, the officials of which were for the greater part foreigners. With the present awakening of the nation it is hoped that the necessity of rescuing this industry from Teutonic control will be realized.

The production of the quarries in Sicily has been exported chiefly through the ports of Syracuse, Pozzalo, and Catania, to the following countries: America, about 500 metric tons; Austria, 5500 metric tons; Ceylon, 104 metric tons; Denmark, 980 metric tons; Egypt, 1500 metric tons; France, 3500 metric tons; Germany, 31,500 metric tons; Greece, 400 metric tons; England, 22,700 metric tons; Holland, 8790 metric tons; Rumania, 1000 metric tons; and Turkey, 200 metric tons. The quantity retained in Italy did not exceed 6500 metric tons.

The principal asphalt deposits in Italy are in the province of Chieti, District of Rome. They were the first Italian deposits to be exploited and for that reason they are today producing less than the Sicilian deposits. The first exploitation was conducted by a German firm, Rek & Co., and accomplished results of notable importance. These deposits have been taken over by the Valle Romano Co., which is at present doing but little work.

[1] *Eng. Min. Jour.*, Mar. 8, 1919.
[2] Les mines italiennes d'asphalte: *Journal du pétrole*, April, 1918.

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The second firm to work the mines in the District of Rome was the Neuchatel Asphalt Co., capitalized at 15,000,000 lire (about $781,500). Since 1915 this company has been less active than in the preceding years, but it furnished, nevertheless, the greater part of the production in 1916. Two-thirds of the asphalt mined by this English firm was taken from the quarries at Gese. At the Piana Monaci property exploratory boring begun in 1916 to determine the extent of the Ponte leads has been suspended and abandoned because of the failure to discover rock of value. At the Pilono opening, that is to say, along the service roads of the San Giorgio mine, well-directed boring has revealed the presence of good asphalt rock in advance of the Cusano lead. The San Giorgio mine has recently opened a quarry near Torretta.

The production of this district in 1917 was as follows:

	Metric Tons.
Powdered asphalt	2,037
Block asphalt	1,212
Mastic	9,055
Refined bitumen	1,304
Bituminous rock	6,645

There are also two small plants working in the district of Galtamsetta, province of Syracuse; their combined production in 1917 was 2000 metric tons of bituminous rock.

Cuba.—The following table, compiled from data furnished by the Pan American Union, shows the extent of foreign shipments of asphalt from Cuba in the last 7 years:

ASPHALT EXPORTED FROM CUBA, 1911–1917

Year.	Quantity, (Long Tons).	Value.	Year.	Quantity (Long Tons).	Value
1911	3,248	$21,629	1915	434	$11,247
1912	15,410	86,303	1916	481	12,486
1913	1,562	30,935	1917 (6 months)	272	7,354
1914	865	19,491			

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BARIUM AND STRONTIUM

By J. B. Pierce, Jr.

The year 1917 witnessed the peak in the production of barium and strontium ores and products. The end of the war witnessed a marked shrinkage in the volume of trade and a cut in value of all barium and strontium products. These industries will find during the year of 1919 whether there is a sufficient volume of domestic business under normal conditions to warrant their survival. Perhaps the problems which these industries will face can be most clearly demonstrated by the following authentic figures regarding barium products in 1914 and 1917:

COMPARISON OF BARIUM STATISTICS, 1914 AND 1917

Article.	Pre-war Price, ex Dock, New York City.	Quantity Imported, 12 Months Ending June 30, 1914.	Price in 1917.	Quantity Sold.	Approximate Quantity Manufactured, 1917.
Barium chloride.....	$32.50 to $38.00 per net ton, including ¼ ct. per lb. duty.	3,100 tons.	$75.00 per net ton, f.o.b. factory.	4,870 tons (net).	6,000 tons (net).
Precipitated barium sulphate (blanc fixe.).	$40.00 per net ton including 20 per cent. duty.	2,376 tons.	$60.00 per net ton, f.o.b. factory.	6,314 tons (net).	6,314 tons (net).
Precipitated barium carbonate.....	$27.00 to $30.00 per net ton including 15 per cent. duty, bags included.	2,500 tons.	$60.00 per net ton, f.o.b. factory.	8,238 tons (net).	8,238 tons (net).
Barium nitrate.....	4¾ cts. per lb. including 25 per cent. duty.	No records; estimated 600 to 800 tons.	11 cts. per lb., f.o.b. factory.	165 tons (net).	4,000 tons (net).
Barium binoxide.....	8 cts. per lb. including duty of 1½ cts. per lb.	3,043 tons.	26 cts. per lb., f.o.b. factory.	2,500 tons (net).	2,500 tons (net).
Barytes (crude ore)....	$15.00 per gross ton including 15 per cent. duty.	32,550 tons.	$6.23 per gross ton, f.o.b. mine.	206,888 tons (net).	217,888 tons (net).
Lithopone.....	.....	3,234 tons.	$116.06 per net ton, f.o.b. factory.	63,713 tons (net).	63,713 tons (net).

From the figures in the above table, it can be seen that the amount of barium products manufactured and sold in the United States during 1917 was 3 to 4 times the amount imported and sold in 1914, and

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as in 1914 there was practically no domestic production, the figures give a fairly accurate measure of the expansion of the domestic market for these products. The table also shows that the price received was approximately double the price at which the imported goods were sold ex dock, duty paid, in 1914.

Undoubtedly the domestic market will continue to consume more than in 1914, but unless adequate protection is given by tariff, it is problematic whether the barium industry can operate at a profit until it is better established.

Barytes

MARKETED PRODUCTION OF CRUDE BARYTES IN THE UNITED STATES

	Short Tons.		Short Tons.		Short Tons.
1901	49,070	1907	89,621	1913	45,298
1902	61,668	1908	38,527	1914	52,747
1903	50,397	1909	61,945	1915	108,547
1904	65,727	1910	42,975	1916	221,952
1905	48,235	1911	38,445	1917	206,888
1906	50,231	1912	37,478	1918	155,241

Figures for the 1918 production of barytes are as follows: Alabama, 1,667 tons; Tennessee, 22,542 tons; Georgia, 69,318 tons, and Missouri 49,094 tons, with 12,620 tons from seven other states.

CRUDE BARYTES MARKETED IN THE UNITED STATES[1]

State.	1916.			1917.			1918.		
	Quantity (Short Tons).	Value.	Average Price Per Ton.	Quantity (Short Tons.)	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price Per Ton.
Alabama	7,631	$27,198	$3.56	1,976	$8,868	$4.49	1,667	$9,408	$5.64
Colorado	481	3,005	6.25	.....	.....	.....	.....	.....	.....
Georgia	104,784	401,295	3.83	111,300	601,895	5.41	69,318	418,178	6.03
Kentucky	11,068	54,995	4.97	6,720	36,084	5.37	(a)	(a)	(a)
Missouri	58,223	365,111	6.27	59,046	391,363	6.63	49,094	393,738	8.02
North Carolina	878	3,246	3.70	1,019	5,080	4.99	(a)	(a)	(a)
Tennessee	32,416	123,986	3.85	16,972	79,058	4.66	22,542	141,844	6.29
Other States(b)	6,471	32,396	5.01	9,855	48,836	4.96	12,620	381,169	6.43
	221,952	1,011,232	4.56	206,888	1,171,184	5.66	155,241	1,044,337	6.73

(a) Included in "Other States."
(b) Includes, 1916 and 1917: California, Nevada, South Carolina and Virginia; 1918: Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia and Wisconsin.

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CRUDE BARYTES IMPORTED FOR CONSUMPTION[1]

Year.	Quantity (Short Tons).	Value.	Year.	Quantity (Short Tons).	Value.
1913	35,840	$61,409	1916	17	$245
1914	24,423	46,782	1917	5	63
1915	2,504	4,877	1918	*Nil.*	*Nil.*

APPARENT CONSUMPTION OF CRUDE BARYTES[1]
(Short tons)

Year.	Sales of Domestic Barytes.	Imports for Consumption.	Apparent Consumption.
1912	37,478	26,186	63,664
1913	45,298	35,840	81,138
1914	52,747	24,423	77,170
1915	108,547	2,504	111,051
1916	221,952	17	221,969
1917	206,888	5	206,893
1918	155,241	0	155,241

CRUDE BARYTES USED IN THE MANUFACTURE OF BARIUM PRODUCTS[1]

	For Barium Chemicals.	For Ground Barytes.	For Lithopone.	Total.
1915	10,216	53,903	44,503	108,622
1916	38,283	75,507	71,898	185,688
1917	49,842	60,132	86,065	196,039

C. H. Gordon gives a most complete description[2] of the formation, extent and quality of the barite deposits of Tennessee.

The methods of mining the ore are practically the same as described in MINERAL INDUSTRY for 1917, except that it has been found that the log washer, now almost universally used to wash the ore, needs additional length. Some washers have been equipped with 30-ft. logs during the year; with these logs, the ore is carried to a higher angle. Most of the newer washers are equipped with an 8-in. stream of water under 60-lb. pressure. It is reported that some of the plants have installed larger pulsating jigs to take care of the fine ore which does not go on to the picking belts. These changes, where made, have improved the quality of the washed ore, producing in some cases ore running 94 to 96 per cent. barium sulphate.

The price of good-grade washed ore averaged about $6.43 per short ton at the mines during 1918, this being an increase of 77 cts. per ton, or 13.3 per cent. increase over the 1917 average price of $5.66 per short ton.

The *Canadian Mining Journal* of March 15, 1918, has a comprehensive description of a new barytes mine at the Premier Langmoir mine

[1] James M. Hill, *Min. Res. of U. S.*, 1917, U. S. Geol. Surv.
[2] "Barite Deposits of the Sweetwater District, East Tennessee," *Res. of Tenn.*, Jan., 1918, Tenn State Geol. Surv.

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in Northern Ontario. The mineral is here associated with silver in both the native and sulphide forms. A complete description of the work done to date is given.

Samuel H. Dolbear[1] described the occurrence of barium carbonate at El Portal, Mariposa County, Calif., at the Hatton manganese mine near Aguila, Ariz., and at the Borden mine near Hollister, San Benito County, Calif. Practically no commercial development has taken place at any of the above prospects.

BARIUM PRODUCTS OF DOMESTIC MANUFACTURE SOLD, 1915–1917[2]

	1915.	1916.	1917.
	Quantity (Short Tons).	Quantity (Short Tons).	Quantity (Short Tons).
Barium chemicals	8,823	16,792	22,503
Ground barytes	51,557	65,440	52,694
Lithophone	46,494	51,291	63,713
	106,874	133,523	138,910

BARIUM CHEMICALS OF DOMESTIC MANUFACTURE SOLD, 1915–1917[2]

Chemical.	1915.	1916.	1917.
	Quantity (Short Tons).	Quantity (Short Tons).	Quantity (Short Tons).
Barium binoxide	(a)	1,980	(a)
Barium carbonate	2,746	6,844	8,238
Barium chloride	2,106	3,643	4,870
Barium nitrate	971	446	165
Barium sulphate (blanc fixe)	(a)	3,337	6,314
Other barium chemicals	3,000	542	2,916
	8,823	16,792	22,503

(a) Included under "Other barium chemicals."
(b) Includes, 1915: binoxide, hydroxide, sulphate, sulphide, and other barium chemicals not specified; 1916: hydroxide and sulphide; 1917: binoxide, hydroxide and sulphide.

IMPORTS OF BARIUM PRODUCTS
(Fiscal year, ending June 30)

	1915.		1916.		1917.		1918.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Baryta, sulphate of, or barytes including baryta earth:								
Unmanufactured, long tons	9,616	$21,087	15	$245	Nil.	Nil.	5	63
Manufactured, long tons	1,755	14,997	Nil.	Nil.	210	3,813	Nil.	Nil.
Blanc fixe, or artificial sulphate of barytes, and satin white or artificial sulphate of lime, pounds	2,233,369	25,748	492,723	11,523	408,163	10,029	179,200	2,376
Lithopone, pounds	6,205,245	195,828	5,122,083	414,573	231,869	20,591	448,000	29,199
Barium carbonate, pounds	844,588	7,864	6	2	804	177	106,288	1,437
Barium binoxide, pounds	4,084,144	311,262	546,442	48,451	Nil.	Nil.	Nil.	Nil.
Barium chloride, pounds	4,686,029	60,532	50	10	6,614	608	Nil.	Nil.

[1] "Possible Sources of Barium Carbonate." *Min. Sci. Press*, May 4, 1918.
[2] *Min. Res. of U. S.*, 1917, U. S. Geol. Surv.

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STATISTICS OF BARYTES IN THE PRINCIPAL COUNTRIES
(Metric tons)

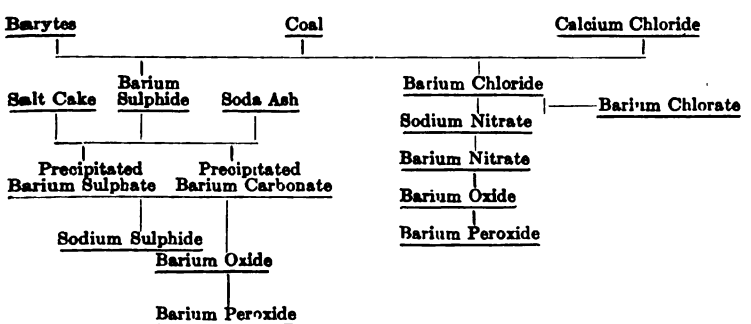
	1912.	1913.	1914.	1915.	1916.	1917.
Austria-Hungary (exports)						
Barium chloride	3,659	4,918	.....	.....	.....	.....
Barytes	2,690	753	.....	.....	.....	.....
Belgium (production)	32,400	12,000	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Canada (production)	421	582	555	499	1,241	3,166
France (production)	13,620	12,236	.....	.....	.....	.....
Baden (production)	15,871	16,445	.....	.....	.....	.....
Bavaria (production)	27,199	27,199	.....	.....	.....	.....
Germany (exports)						
Barytes	142,681	158,065	.....	.....	.....	.....
Barium white	8,242	7,647	.....	.....	.....	.....
Barium chloride	8,096	5,649	.....	.....	.....	.....
Barytes (imports)	18,666	19,466	.....	.....	.....	.....
Italy (production)						
Barytes, crude	13,420	12,970	12,970	17,850	21,650	19,000
Barytes (imports)	1,986	1,771	1,409	1,319	1,398	.....
Barytes (exports)	381	234	210	3,288	2,755	.....
Spain (production)	1,096	3,049	.....	4,218	10,508	10,147
Sweden (imports)	644	610	730	1,665	.....	.....
United Kingdom (production)	43,453	48,792	49,718	63,483	77,258	66,612
United States (imports)	27,093	37,490	26,025	3,460	149	84
United States (production)	34,009	41,105	47,865	98,500	202,355	187,689

Ground Barytes.—The price of this article varied for the pure article from $30 to $36 per net ton during 1918, for the off-color from $20 to $24 per net ton.

Barium Products

No authentic production figures are available at the date of writing this article for barium products during 1918. It is quite certain, however, that a sharp reduction from the figures of 1916 and 1917 will be shown in all the products.

The manufacturing of barium products is shown diagrammatically below; no radical changes having been introduced during the year 1918.



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STRONTIUM

Celestite (Crude Strontium Sulphate).—The United States Geological Survey reports 4035 short tons of strontium ores valued at $87,700, 10 per cent. being strontianite, mined in the United States during 1917. All of this was mined in California, Washington, and Texas. The 1917 production, however, was unusual, as the 1916 output amounted to only 250 tons, and in 1918 it fell again to 400 tons. The value of the 1916 production was $3650, and of the 1918, $20,000. The Survey reports 1700 tons of English celestite imported in 1917. No figures for 1918 are available at this writing. No exports of strontium ore have been reported.

Strontium Products.—The Survey reports sales of strontium carbonate and nitrate in 1917 totaling 3,000,000 lb., of which the nitrate constituted the greater part. Several thousand pounds of sulphide is also reported as having been sold in 1917. Strontium nitrate sold for 25 cts. per lb. and the carbonate for about 40 cts. per lb. during 1917.

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BISMUTH

Most of the bismuth of the world is obtained from Bolivia, where it is produced as crude bullion, which goes to London for refining, the well-known firm of Johnson, Mathey & Co. being specialists in that. For many years that concern, together with some German producers, had an absolute control of the world's market, and they were very dictatorial about it. In recent years a considerable quantity of bismuth has been produced in the United States as a by-product of electrolytic lead refining. The American producers are supposed to have an understanding with Johnson, Mathey & Co., but that is only a surmise, for all parties preserve great secrecy. It is safe to say, however, that anyone who is contemplating the competitive production of bismuth should be careful as to his movements.

In general, the pyrometallurgy of bismuth is similar to the metallurgy of lead, but a great deal of skill is required in adequately refining the crude metal, and the value of refined bismuth varies greatly according to its character. The best grade of the metal is that which is used for pharmaceutical purposes, which constitutes the major consumption, and commands a price that is far superior to what is fetched by ordinary metal, suitable for making fusible alloys and for other industrial purposes.

The electrolytic lead refiners recover bismuth in their slimes when they are working up lead bullion that contains any bismuth. The procedure in recovering bismuth from the slimes has not been described in technical literature, but no doubt the process is more or less intricate. In brief, the essential part of the metallurgy of this metal, viz. the refining, constitutes an art that very few persons know about, and they have taken very good care to keep the knowledge to themselves.

Bismuth prices do not fluctuate greatly. During 1917, the price was $3.50 per lb. for the last half of the year; in 1918, in February and March, the price dropped to $3.35 per lb., but returned to $3.50 per lb. and held there during the remainder of the year.[1]

The following table gives the imports into the United States for the fiscal years since 1908: (*a*)

[1] W. R. Ingalls, *Eng. Min. Jour.*, Jan. 11, 1919.

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Year.	Quantity, Lb.	Value.
1908	225,833	$313,919
1909	176,729	274,662
1910	200,221	316,838
1911	178,298	321,360
1912	166,980	305,282
1913	151,030	257,176
1914	133,190	241,448
1915	34,237	72,587
1916	64,821	155,925
1917	88,465	196,113
1918	85,611	208,098

(a) Dept. of Commerce.

Australia.—At the Kingsgate mine, New South Wales, a mill to dress 25 tons daily of sorted Bi_2S_3-MoS_2 ore is being erected, to be ready early in April, 1919.

The ore occurs as small "pipes" scattered through a large area of ground, making mining costs rather high.

PRODUCTION OF BISMUTH MINERALS IN AUSTRALIA
(Tons of 2240 lb.)

Year.	Queensland.	New South Wales.	Tasmania.
	Tons. (b)	Tons.	Tons.
1906	6.5	25.9	.....
1907	6.3	16.3	.....
1908	22.7	8.7	.....
1909	10.3	8.6	.....
1910	21.0	6.4	.....
1911	9.8	7.9	.....
1912	5.0	5.8	.....
1913	1.1	9.0	5.0
1914	0.9	15.0	5.6
1915	2.6	18.0 (a)	5.5
1916	3.6	30.0	3.5
1917	4.0	....	4.0
1918	21.0	....	4.6

(a) Estimated. (b) Exclusive of bismuth taken with tungsten; for output of bismuth-tungsten ore see statistical tables at end of volume.

Bolivia.—By far the largest bismuth-producing country is Bolivia. The amount of the production in recent years is given in the accompanying table. The value of the output in 1915 was $1,085,964.

PRODUCTION OF BISMUTH ORE IN BOLIVIA

Year.	Quantity, Metric Tons.
1911	550
1912	478
1913	422
1914	460
1915	570

Spain.—Spain in 1917 produced 13,900 metric tons of bismuth ores, valued at $1439.

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Uses

The most important use of bismuth at present is as a component of fusible alloys. The metal has a low melting point (260° C.), but it forms with other metals alloys having much lower melting points. Thus, an alloy of bismuth, lead, tin, and cadmium melts below the boiling point of water. Bismuth is occasionally added to the alloy from which stereotype plates are cast when a specially clear impression of the type is required. In this use the molten alloy is not poured until it begins to thicken. Bismuth is also a component of the alloy used for silvering mirrors.

Safety plugs for boilers are made of an alloy containing bismuth which fuses at a temperature just above the boiling point of water. Automatic sprinklers or fire extinguishers placed in the ceilings of buildings are also sealed with an alloy containing bismuth; the rise in temperature, caused by a fire, immediately melts the fusible plugs, causing jets of water to spray all over the room. Electric fuses are sometimes made of a bismuth alloy, and are so constructed that if too heavy a current is passed through them the easily fusible wire melts, causing a disconnection and preventing damage to instruments or appliances within the circuit. In making solders the melting point can be lowered if bismuth is alloyed with them, and soldering can be effected under boiling water if the right proportion is present. The metal is useful in the process of tempering steel. The exact degree of heat required can be fixed by using baths of molten alloys containing bismuth, which can be made up in various proportions giving fixed melting points. Fusible alloys containing bismuth are used for taking casts of objects which would be destroyed by much heat and for amalgams and solders in dental work. Salts of bismuth are used in porcelain-painting and enameling, and in staining glass.

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BORAX

All the Allied nations' supply of borax or boron compounds has been obtained from deposits located on the North and South American continents. The English corporation, Borax Consolidated, controls all the accessible deposits in Peru, Chile, and Bolivia, though there are deposits still in these countries on which no work has been done due to the fact that they are too remote and inaccessible.

The entire United States production is obtained from the colemanite deposits of Inyo and Los Angeles counties, in California. The 1918 output amounted to 88,772 tons, valued at $1,867,908, as compared with 109,944 tons, valued at $2,561,958 in 1917, according to the California State Mining Bureau.

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal years ending June 30)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1912	6,409	$604	22,784	$3,856	276,496	$10,540
1913	11,768	882	16,267	2,038	362,400	13,897
1914	466	64	220	29	527,201	22,390
1915	*Nil.*	.....	*Nil.*	.....	401,684	18,002
1916	*Nil.*	.....	*Nil.*	.....	424,219	22,145
1917	83	3	*Nil.*	.....	404,210	24,590
1918	*Nil.*	.....	*Nil.*	.....	195,650	14,087

PRODUCTION OF BORATE ORES IN CALIFORNIA (*a*)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1905	46,334	$1,019,158	1910(*d*)	42,357	$1,201,842	1915(*d*)	67,003	$1,677,099
1906	58,173	1,182,410	1911(*d*)	53,330	1,569,151	1916(*d*)	103,525	2,409,459
1907	53,412	1,200,913	1912(*d*)	42,315	1,127,813	1917(*d*)	108,875	3,609,632
1908	22,200	1,117,000	1913(*d*)	58,051	1,491,530	1918(*d*)	88,794	2,179,830
1909	16,628	1,163,960	1914(*d*)	62,100	1,464,400			

(*a*) Reported by the California State Mining Bureau. (*b*) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (*c*) Spot value. (*d*) U. S. Geol. Survey, crude.

Peru.—The exports of borax from Peru amount to about 2000 tons each year, writes a correspondent in the *Statist*. The Peruvian Government derives from this product an export tax of 2 cts. per ton. The deposits are extensive, and are situated in the southern part of the Republic, in the neighborhood of Arequipa, and are owned and worked, at least in part,

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by an English company. The great difficulty has been and is the question of transportation, as everything has to be conveyed over a great range of mountains to get to and from the coast. This obstacle has hitherto proved an effective barrier to the development of the district.

Just before the outbreak of the war, the English company concerned was in negotiation with the Peruvian Government with a view to building a railway to facilitate the development of this area. It was estimated that the line would cost about £300,000, but the project had to be abandoned at the outbreak of the war. It is sincerely hoped that when the war is over the railway scheme will be reconsidered. It would have the effect not merely of developing the borax deposits, but would enable various enterprises to be started in a highly promising region of Peru.

SOME OF THE PRINCIPAL SUPPLIES OF BORAX MATERIALS
(In metric tons)

Year.	Chile.	Germany. (b)	Italy.			United States. (c)	Total. (d)
			Borax, Refined. (e)	Boric Acid.			
				Crude.	Refined. (e)		
1903	16,879	159	.....	2,583	.....	31,232	50,853
1904	16,733	135	569	2,624	314	41,407	61,782
1905	19,612	183	1,007	2,700	749	42,036	66,287
1906	28,996	161	1,062	2,561	562	52,774	86,116
1907	28,374	114	881	2,305	466	47,945	80,085
1908	35,039	128	1,024	2,520	429	22,680	61,820
1909	32,218	149	1,110	2,431	578	37,589	74,075
1910	35,192	167	912	2,502	695	38,426	77,894
1911	45,558	160	738	2,648	444	48,381	97,929
1912	43,356	224	813	2,309	760	38,388	85,850
1913	(a) 40,000	(a) 200	1,071	2,410	743	52,600	97,024
1914	34,203	.....	1,164	2,537	838	50,609	94,187
1915	.....	.....	829	2,497	1,277	60,785	.....
1916	.....	.....	554	2,293	1,114	93,918	.....
1917	.....	.....	.....	2,335	.....	98,771	.....

(a) Estimated. (b) Boracite. (c) Crude borax. (d) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (e) Obtained by treating a part of the crude boric acid reported for the same year.

Uses of Borax and Boron

The largest consumer of borax at present is the enamel industry. Due to no importation of enameled ware from abroad, the enameling industry in the United States has become exceedingly active. For the purpose of obtaining a satisfactory enamel, large quantities of borax are used, together with other materials.

Another important use for boron is in the copper industry. Metallic boron or some compounds of boron incorporated into molten copper act as a scouring agent, and copper castings of high electrical conductivity and of dense quality are obtained by its use. This is an important dis-

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covery, especially in the manufacture of electric machinery, making it possible to use cast copper therein.

Metallic boron, or other compounds of metallic boron, are also used in making aluminium bronzes of great strength; in hardening and strengthening aluminium castings; and also in manufacturing parts of nickel.

Experiments on steel have shown that ferroboron acts somewhat similar to ferrovanadium. Experiments in France showed remarkably strong and tough steels were thus made, using 0.5 to 2 per cent. of boron. The results have not been properly followed up, partly on account of the difficulty in getting ferroboron; no one, as yet, has taken up its regular manufacture, and steel makers can hardly be blamed, in these times, for not having as yet thoroughly explored its possibilities as an addition to steel.

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BROMINE AND IODINE

BROMINE

Bromine is derived from bittern left after extracting salt from the brine pumped from deep wells at Mount Pleasant, Midland, Saginaw, St. Charles, and Bay City in Michigan; at Pomeroy in Ohio; and at Mason, Hartford, and Malden in West Virginia.

The element bromine does not occur in native form, but is derived in large quantities from natural brines. It exists in all sea water and in most mineral water and salt springs, and has been found in giant kelp. Bromine is at ordinary temperature a volatile, heavy, mobile liquid of a reddish-brown color, giving off reddish-brown vapor. The vapor when inhaled dilute resembles chlorine in smell and in attacking the throat and nose, but in addition it has a very harmful effect on the eyes.

Bromine is used in many chemical reactions as an oxidizer instead of chlorine, also in dissolving gold and separating it from platinum and silver, and in manufacturing disinfectants, bromine salts, and aniline colors. Perhaps the best known and most widely used bromine salts are bromide of silver, used in photography, and potassium bromide, used in medicine where it is desirable to depress the nervous system. Because of its harmful effect on the eyes, nose, and throat, it has been used in gas warfare.

Production.—The quantity of bromine marketed in 1918 increased nearly 93 per cent. over the production in 1917. The marketed output is given in the following table:

MARKETED PRODUCTION OF BROMINE IN THE UNITED STATES (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1903	598,500	$167,580	1911	651,541	$110,902
1904	897,100	269,130	1912	647,200	145,805
1905	1,192,758	178,914	1913	572,400	115,436
1906	1,283,250	165,204	1914	576,991	203,094
1907	1,379,496	195,281	1915	855,857	856,307
1908	760,023	73,783	1916	728,520	951,932
1909	569,725	57,600	1917	895,499	492,703
1910	245,437	31,684	1918	1,727,156	970,099

(a) U. S. Geological Survey.

To increase the domestic supply of bromine the Government had additional brine wells drilled in Michigan early in 1918. The quantity of bromine marketed in the 6 months ending June 30, 1918, as reported

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by the nine producers to the United States Geological Survey, was 842,453 lb., as compared with 895,499 lb. marketed in the year 1917. The output for the first quarter of the year was 350,234 lb., and that for the second quarter, after the new brine wells in Michigan had been completed and the plants improved by rebuilding, was 492,219 lb., a very great increase.

A large part of the output is not marketed as bromine, but in the form of potassium bromide, sodium bromide, and other salts. The figures given include the bromine content of these salts. There are now ten producers.

During the first 3 months of 1918 four of the plants were idle because they were rebuilding or short of labor, but on July 1 nine were operating and one was nearly ready to resume work.

WHOLESALE PRICE PER POUND OF BULK BROMINE IN NEW YORK CITY, 1915–1917

	1915.	1916.	1917.
January	$0.40–$0.50	$5.00–$6.50	$1.40–$1.50
February	0.40– 0.50	5.00– 6.50	1.40– 1.50
March	0.40– 0.50	5.00– 6.50	1.30– 1.40
April	0.40– 0.50	Not quoted.	1.30– 1.40
May	0.40– 0.50	4.75– 5.25	0.80– 1.00
June	0.85– 0.87	3.50	0.85– 1.00
July	0.85– 0.87	3.50	0.55– 0.60
August	0.85– 0.87	2.40– 2.50	0.55– 0.60
September	1.00– 1.25	1.30– 1.40	0.55– 0.60
October	1.25– 1.60	1.20– 1.30	0.55– 0.60
November	1.50– 1.75	1.40– 1.50	0.55– 0.60
December	1.50– 1.75	1.40– 1.50	0.60– 0.65

IODINE

No iodine is produced in the United States, although seaweed along the coast forms a possible source. Some iodine has been recovered from seaweed in other countries. The only important source, however, is in the nitrate deposits in Chile, which are estimated to contain on the average 1 part of iodine to 1000 of sodium nitrate. The methods of production have been described in previous volumes of MINERAL INDUSTRY.

The imports of iodine into the United States are given in the following table:

Year.	Crude and Resublimed.	
	Pounds.	Value.
1911	423,408	$ 841,740
1912	379,311	737,109
1913	240,045	525,959
1914	463,333	951,308
1915	612,926	1,332,387
1916	2,033,068	5,158,265
1917	609,641	1,363,468
1918	407,333	843,302

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CADMIUM[1]

Cadmium is marketed in two forms, as metallic cadmium, in sticks or bars, and as cadmium sulphide, the pigment. The metal has found its greatest field of use in this country as a component of an easily fusible alloy that is used in automatic fire extinguishers. The sulphide is used to some extent in paints, but chiefly to give color and luster to glass and porcelain.

The metal was first made in this country by the Grasselli Chemical Co. in 1906. Since 1910, the production has grown rapidly until in 1917 the production was 207,408 lb. The output of cadmium sulphide for the same years increased from 22,176 to 50,169 lb. The market for cadmium was a little slow in the first half of 1918, stocks accumulated to some extent, and production was somewhat curtailed. In the first 8 months the output was 118,700 lb. of metallic cadmium and 36,500 lb. of the sulphide. The stocks on hand Aug. 31 were 161,000 lb. of metallic cadmium and 23,500 lb. of the sulphide. Production for the year amounted to 127,164 lb. of metal and 51,702 lb. of sulphide. Other companies now manufacturing one or both forms of cadmium are the American Smelting & Refining Co.; the U. S. Smelting, Refining & Mining Co. (including the lead smelter at Midvale, Utah, and the electrolytic zinc plant at Kennett, Cal.), the Krebs Pigment & Chemical Co., and the Midland Chemical Co. To these may shortly be added the Anaconda Copper Mining Co. (electrolytic zinc plant at Great Falls, Mont.); the Judge Mining & Smelting Co., Park City, Utah; the E. I. Du Pont de Nemours & Co., Wilmington, Del.; and the Consolidated Mining & Smelting Co., Ltd., of Trail, B. C., with the possibility of still others. Several plants producing cadmium-bearing residues have sold them to other companies already equipped to recover the metal. This points the way to custom cadmium-reduction plants large enough to handle economically the product of those plants whose output is too small to justify individual reduction plants.

Previous to the development of a sufficient domestic production, considerable amounts were imported, but this has now been entirely discontinued, and now large amounts are exported. Exports of cadmium in 1918 were 62,320 lb., of which 30,440 lb. went to France and 20,000 lb. to Japan.

[1] Abstracted, with some additions, from "The Cadmium Supply of the United States," by C. E. Siebenthal, *Bull. Am. Inst. Min. Eng.*, 144, Dec., 1918; *Trans.*, 60, 185.

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PRODUCTION OF CADMIUM IN THE UNITED STATES (a)

Year.	Metal, Lb.	Value.	Sulphide, Lb.	Value.	Total Cadmium Content, Lb.	Total Value.
1912	52,508	39,875	8,998	6,400	59,504	46,275
1913	54,198	41,838	17,302	12,136	67,650	53,974
1914	91,409	81,205	22,723	20,241	109,076	101,446
1915	91 415	108,443	10,624	12,057	99,675	120,500
1916	135,212	210,931	22,176	27,942	152,453	238,873
1917	207,408	305,097	50,169	70,939	246,412	376,036
1918	127,164	188,203	51,702	70,315	167,440	258,518

(a) U. S. Geol. Surv.

Sources

There are several cadmium minerals, but none of these occur in profitable quantities as ores. The cadmium of commerce is derived from zinc minerals and ores, in almost all of which it occurs in minute quantity, the ratio being about 1 of cadmium to 200 of zinc. Cadmium behaves metallurgically almost the same as zinc and hence constitutes a fraction of 1 per cent. of almost all spelter. The sources of cadmium that have been utilized are zinc ores treated by fractional distillation, lead-furnace bag-house "fumes," and residues from the purification vats of electrolytic zinc plants and lithopone plants.[1]

A canvass of lead smelters, electrolytic zinc reduction and refining plants, lithopone plants, and a few typical brass works, indicates that about 600 tons accumulates annually, and there is on hand approximately 1200 tons in stocks of fumes and residues. Not all the stocks are rich enough for the cadmium to be commercially recovered, but perhaps material that carries 1000 tons is suitable for treatment. The average recovery of cadmium is about 75 per cent. We may therefore estimate 750 tons of recoverable cadmium in residues in stock. An increase in the number and capacity of electrolytic zinc plants will correspondingly increase the annual accumulation of cadmium.

Previous to the war Germany was the main source of cadmium outside of the United States. Production statistics have been lacking since the war, but the *Metal Bulletin* states that the upper Silesian Spelter Works in Katowitz produced 9905 kg. of cadmium in 1918, against 8568 kg. in 1917.

Reduction Capacity

The maximum capacity for metallic cadmium reported by producers is 29,000 lb. a month, or about 175 tons a year. This capacity will be increased by the entrance into the producing list of the electrolytic zinc plants mentioned above. If the price of cadmium and the demand

[1] The reader is referred to the original article for the details of the methods of production from the various sources.

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for it should justify expansion, the producing capacity could no doubt be brought up with reasonable promptness to 500 tons or more yearly. The price of cadmium will be the deciding factor also in determining what grade of cadmium fumes can be worked at a profit.

Prices

In 1875, cadmium was quoted in the United States at $3.20 a pound. In 1886, the average price for the total output of Germany was 80 cts. per lb.; but in 1890 and 1892, it fell off to 38 cents. In 1897, because of certain purchases by the Imperial Government, the price rose to $1.23 a pound. In 1907, after the United States began making cadmium, the German average price was 84 cents. The price in the United States went down to 53 cts. in 1909, but it has been rising since. In 1916, the average price was $1.56 per lb.; in 1917, $1.47, and in 1918, $1.48.

New Uses

The war interest in cadmium centered mainly in its employment as a substitute for tin, but more of it was probably put into bronze telegraph and telephone wires.

The large quantity of tin used in making food containers for rationing the American and Allied armies, combined with the lack of shipping and the loss of several cargoes of tin, produced a critical scarcity of tin in this country and led to Government control of its distribution as well as to a campaign for its conservation. One method of saving tin is to substitute cadmium for it in solder. In the last year of the war the Government and certain large concerns began experiments with cadmium solders as a means of saving tin. The results of these experiments were promising, but the demand for tin decreased, and the armistice was signed before cadmium solders became widely used.

Cadmium was used by European nations during the war for some strictly military purposes, but little exact information is available to show these purposes.

The first of the belligerent nations to make large use of cadmium as a substitute for tin in solders was Germany, which from the beginning of the war was cut off by the blockade almost entirely from the world's sources of tin. Solders containing 10 per cent. of cadmium were used in Germany early in the war, and some were reported to contain as high as 30 per cent. of cadmium and only 2 per cent. of tin instead of the customary 40 or 50 per cent.

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CEMENT

By Robert W. Lesley

The war made a marked impression upon the Portland cement industry during the year 1918. Referring back to the figures for the preceding year, it may be said that conditions were absolutely reversed. The year 1917 showed the largest production of Portland cement since the establishment of the industry in this country, while 1918 shows the lowest production since the year 1909, when the industry was beginning to grow rapidly in the United States. Table I gives the total production and value for the years, 1916–17–18.

TABLE I.—PRODUCTION OF MARKETED CEMENT IN THE UNITED STATES BY CLASSES (a)

Class.	1916.		1917.		1918.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	94,552,296	$104,258,216	90,703,474	$122,775,088	70,915,508	$113,153,513
Natural } Puzzolan	842,137	430,874	639,456	435,370	432,966	401,341
Total	95,394,433	$104,689,090	91,342,930	$123,210,458	71,348,474	$113,554,854

(a) U. S. Geol. Surv.

The war also had an important influence upon the distribution of Portland cement, reversing again the status of 1917. In the latter year the greatest increase in output was in the plants in the far-western and Pacific Coast districts, while the figures for 1918 show that these territories were the scenes of the largest decrease in output. An examination of the tables which follow, showing the production of the country divided into geographical districts and into states, demonstrates the effect of war restrictions.

It was not long after hostilities with Germany were begun that the Government took over the control of the product of the Portland cement industry, as it did in the case of many other great industries in the country; the effect of this Government action was marked in the distribution of cement, which was practically limited in many ways to war uses, and as the tables show, the plants evidencing the least reduction in output were those whose material was distributed in territory where

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the Government was doing large construction in munition works, terminals and other Governmental works.

TABLE II.—PORTLAND CEMENT, 1917-1918, BY DISTRICTS (a)

District.	Production and Shipments (Barrels).			Average Factory Price per Barrel.		
	1917.	1918.	Percentage of Change.	1917.	1918.	Percentage of Change.
Lehigh district (eastern Pennsylvania and western New Jersey):						
Shipments	24,423,641	19,351,123	−20.8	$1.220	$1.519	+24.5
Production	24,423,507	19,701,820	−19.3	.....	.....	.....
Stock	2,166,106	2,512,123	+16.0	.....	.....	.....
New York State:						
Shipments	5,408,726	4,074,159	−24.7	1.304	1.612	+23.6
Production	5,417,530	4,095,588	−24.4	.....	.....	.....
Stock	804,811	832,271	+ 3.4	.....	.....	.....
Ohio and western Pennsylvania:						
Shipments	7,248,264	6,231,702	−14.0	1.382	1.540	+11.4
Production	7,345,416	6,439,179	−12.3	.....	.....	.....
Stock	653,275	845,373	+29.4	.....	.....	.....
Michigan and northeastern Indiana:						
Shipments	4,835,304	4,183,260	−13.5	1.427	$1.670	+17.0
Production	5,263,810	4,106,467	−22.0	.....	.....	.....
Stock	870,544	790,495	− 9.2	.....	.....	.....
Southern Indiana and Kentucky:						
Shipments	2,386,347	1,960,109	−17.9	1.352	1.618	+19.7
Production	2,517,257	1,609,475	−36.1	.....	.....	.....
Stock	611,426	246,242	−59.7	.....	.....	.....
Illinois and northwestern Indiana:						
Shipments	10,233,233	7,894,542	−22.9	1.367	1.525	+11.6
Production	10,927,990	7,169,038	−34.4	.....	.....	.....
Stock	1,823,967	1,088,775	−40.3	.....	.....	.....
Maryland, Virginia and West Virginia:						
Shipments	3,109,098	2,308,193	−25.8	1.265	1.623	+28.3
Production	3,122,936	2,281,629	−26.9	.....	.....	.....
Stock	305,948	268,384	−12.3	.....	.....	.....
Tennessee, Alabama and Georgia:						
Shipments	3,686,359	3,092,425	−16.1	1.233	1.524	+23.6
Production	3,676,354	2,990,734	−18.6	.....	.....	.....
Stock	220,582	118,988	−46.1	.....	.....	.....
Iowa, Missouri and Minnesota:						
Shipments	11,510,753	8,712,597	−24.3	1.485	1.631	+ 9.8
Production	11,774,381	9,478,051	−19.5	.....	.....	.....
Stock	1,124,854	1,937,902	+72.3	.....	.....	.....
Nebraska, Kansas, Oklahoma, and central Texas: (a)						
Shipments	7,405,415	5,365,848	−27.5	1.453	1.690	+16.3
Production	7,710,365	5,370,181	−30.4	.....	.....	.....
Stock	642,191	654,876	+ 2.0	.....	.....	.....
Rocky Mountain States (Colorado, Utah, Montana, and western Texas):						
Shipments	3,197,284	2,175,874	−31.9	1.664	1.850	+11.2
Production	3,261,675	2,288,953	−29.8	.....	.....	.....
Stock	255,056	375,042	+47.0	.....	.....	.....
Pacific Coast States (California, Washington and Oregon):						
Shipments	7,259,050	5,565,676	−23.3	1.399	1.730	+23.7
Production	7,372,981	5,550,548	−24.7	.....	.....	.....
Stock	825,078	783,479	−10.5	.....	.....	.....
Total:						
Shipments	90,703,474	70,915,508	−21.8	1.354	1.596	+17.9
Production	92,814,202	71,081,663	−23.4	.....	.....	.....
Stock	10,353,838	10,453,950	+ 1.0	.....	.....	.....

(a) E. F. Burchard, U. S. Geol. Surv.

The Government control was also evidenced in the restriction in fuel for the cement industry, and in the limitation of railroad facilities, cars, etc.

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TABLE III.—PORTLAND CEMENT, 1917-1918, BY STATES (a)

State.	Production and Shipments (Barrels).			Average Factory Price per Barrel.		Active Plants, 1918.
	1917.	1918.	Percentage of Change.	1918.	Percentage of Change.	
California:						
Shipments	5,659,547	4,238,424	− 25.1	$1.673	+27.5	10
Production	5,653,362	4,354,074	− 23.0			9
Stock	463,256	528,026	+ 14.0			
Illinois:						
Shipments	4,378,233	3,703,471	− 15.4	1.538	+10.6	4
Production	4,659,990	3,594,038	− 22.9			4
Stock	739,763	646,255	− 12.6			
Indiana:						
Shipments	8,148,678	6,205,326	− 23.8	1.544	+13.5	5
Production	8,705,831	5,291,851	− 39.2			5
Stock	1,760,532	822,888	− 53.3			
Iowa:						
Shipments	4,428,765	3,188,669	− 28.0	1.701	+ 9.7	4
Production	4,626,141	3,626,455	− 21.6			4
Stock	618,811	1,055,540	+ 70.6			
Kansas:						
Shipments	3,772,884	2,586,834	− 31.4	1.631	+16.8	7
Production	4,015,169	2,499,723	− 37.7			7
Stock	409,393	326,273	− 20.3			
Michigan:						
Shipments	4,313,771	3,618,088	− 16.1	1.680	+18.4	10
Production	4,688,899	3,554,872	− 24.2			10
Stock	701,919	635,447	− 9.3			
Missouri:						
Shipments	5,800,988	4,515,695	− 22.2	1.579	+11.0	5
Production	5,882,240	4,738,596	− 19.4			5
Stock	404,624	676,552	+ 67.2			
New York:						
Shipments	5,408,726	4,074,159	− 24.7	1.612	+23.6	8
Production	5,417,530	4,095,588	− 24.4			8
Stock	804,811	832,271	+ 3.4			
Ohio:						
Shipments	1,565,394	1,289,887	− 17.6	1.712	+15.1	5
Production	1,566,209	1,440,859	− 8.0			5
Stock	126,239	262,142	+107.7			
Oklahoma:						
Shipments	1,736,761	1,218,841	− 29.8	1.807	+19.2	3
Production	1,772,466	1,246,515	− 29.7			3
Stock	70,708	89,188	+ 26.1			
Pennsylvania:						
Shipments	27,709,442	22,238,689	− 19.7	1.511	+21.3	21
Production	27,752,838	22,628,901	− 18.5			21
Stock	2,455,588	2,840,810	+ 15.7			
Texas:						
Shipments	2,358,944	1,918,919	− 18.7	1.719	+10.8	5
Production	2,436,398	1,971,867	− 19.1			5
Stock	222,537	289,779	+ 30.2			
Utah:						
Shipments	899,599	549,593	− 38.9	1.680	+ 3.4	3
Production	929,730	570,310	− 38.7			3
Stock	106,580	133,465	+ 25.2			
Washington:						
Shipments	1,403,191	1,116,754	− 20.4	1.894	+12.3	5
Production	1,513,792	931,489	− 38.5			5
Stock	385,707	214,220	− 44.5			
Other States: (b)						
Shipments	13,118,551	10,452,159	− 20.3	1.628	+21.0	20
Production	13,193,607	10,536,525	− 20.1			20
Stock	1,083,370	1,101,094	+ 1.6			
Total:						
Shipments	90,703,474	70,915,508	− 21.8	1.596	+17.9	115
Production	92,814,202	71,081,663	− 23.4			114
Stock	10,353,838	10,453,950	+ 1.0			

(a) E. F. Burchard, U. S. Geol. Surv.
(b) 1917: Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, New Jersey, Oregon, Tennessee, Virginia, and West Virginia. 1918: Nebraska omitted.

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The result of all this was that the production of Portland cement showed a decrease of 23.4 per cent. as compared with 1917. While the coal restrictions permitted many of the works to operate in excess of 50 per cent. of their capacity, the average throughout the United States shows that only about 54 per cent. of the total capacity of the manufacturing plants in the country was utilized during 1918. As already explained, the reductions in output were most largely marked in the territories which had little or no Government work within their area.

Operating under the direction of the War Trade Board, a section on building materials was established in Washington and through this section, coöperating with a committee of the Portland Cement Association, the work of the cement manufacturers was coördinated with the Government desires and the successful operation of the policy pursued was evidence of the great advantage in times of war and financial stress of well-organized and well-officered organizations such as the Portland Cement Association, which practically put its best men and all its facilities at the disposition of the Government.

While both shipments and production decreased in 1918, the average factory price per barrel for the whole country shows an increase of $0.242, or 17.9 per cent., over 1917. Again a reversal of conditions is shown, for, while in 1917 the largest increase in price was in the far-western and Pacific Coast territory, the present year shows that the eastern states, especially the Lehigh district comprising eastern Pennsylvania and western New Jersey, have been most benefitted by the higher price; but this again has been largely offset by the great increase in the cost of coal, limestone, machinery, and last but not least, labor, as it was in this section of the United States that most of the great shipbuilding of the country was done and that the Government was most active in the field of construction and munitions.

The average factory price per barrel shown in Table IV following, was $1.596 in 1918, as compared with $1.354 in 1917.

TABLE IV.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870–1917

1870–1880	$3.00	1895	$1.60	1907	$1.11
1881	2.50	1896	1.57	1908	0.85
1882	2.01	1897	1.61	1909	0.813
1883	2.15	1898	1.62	1910	0.891
1884	2.10	1899	1.43	1911	0.844
1885–1888	1.95	1900	1.09	1912	0.813
1889	1.67	1901	0.99	1913	1.005
1890	2.09	1902	1.21	1914	0.927
1891	2.13	1903	1.24	1915	0.860
1892	2.11	1904	0.88	1916	1.103
1893	1.91	1905	0.94	1917	1.354
1894	1.73	1906	1.13	1918	1.596

Referring back to Table I, it will be noted that the natural cement industry, which has been dwindling away for many years, shows a decrease

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from 639,456 bbl. in 1917 to 432,966 bbl. in 1918, thus indicating that following the total elimination of puzzolan cement this old-established American product will, unless revived by manufacturing improvements, ultimately give way to the artificial Portland cement.

Table IV shows the average price per barrel of Portland cement from 1870 to 1918, and as a matter of comparison the figure for 1918 may be said to be identical with that of 1895, no advance being shown in the average price of the material after an interval of 23 years, when in point of fact most of the other commodities entering into the field of building construction have in the same period advanced from 50 to 100 per cent. The increase is caused by the higher price of labor and material, factors which certainly have affected the cement industry, within the last two war years especially.

Table V shows the fuel used in burning Portland cement in the various plants operating, and indicates how largely coal has superseded all other fuels used in the industry.

TABLE V.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT (a)

Fuel.	1917.				1918.			
	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.
Coal	93	636	76,410,379	82.2	93	605	58,605,244	82.4
Coal and oil	1	24	6,492,713	7.0	2	28	5,188,915	7.3
Coal and gas	2	14			1	4		
Oil	18	103	8,680,313	9.4	16	99	6,442,165	9.1
Coal, oil and gas	1	5	1,230,797	1.4	2	13	845,339	1.2
Oil and gas	.....	.....			.....	.....	.....	.....
Producer gas	1	1			.....	.....	.....	.....
Natural gas	1	6			.....	.....	.....	.....
Total	117	789	92,814,202	100.0	114	749	71,081,663	100.0

(a) U. S. Geol. Surv.

During the year 1918 two new plants were brought into production, the Old Mission works at San Juan de Bautista, Cal., and the Three Forks, at Hanover, Mont. One hundred and fourteen plants were in operation and six plants were idle.

Following the steadily decreasing output of puzzolan and natural cements, the imports of foreign cement, the statistics for which are given in Table VI below, show even more remarkable figures. As against imports which in the early 90's ran as high as 3,000,000 bbl. per annum, the imports for 1918 dwindled to the small amount of 305 barrels. In 1917 the imports were 2323 barrels.

The exports, given in Table VII, show a decrease from 2,586,215 bbl. in 1917 to 2,252,446 in 1918. While the quantity diminished, which was

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a natural condition due to the limited ship room, the price of the material shipped shows an increase in value of 11 per cent.

TABLE VI.—IMPORTS OF FOREIGN CEMENT, IN BARRELS OF 380 LB.

1883	456,418	1895	2,997,395	1907	2,033,438
1884	585,768	1896	2,989,597	1908	842,121
1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	85,470
1890	1,940,186	1902	1,963,023	1914	120,906
1891	2,988,313	1903	2,251,969	1915	42,218
1892	2,440,654	1904	968,409	1916	1,836
1893	2,674,149	1905	896,845	1917	2,323
1894	2,638,107	1906	2,273,493	1918	305

While for a number of years some of the large cement companies have entered the foreign field, there was organized in the fall of 1918 under the Webb Act a corporation entitled the Cement Export Co. which is to enter the foreign field in a large way and distribute American Portland cement all over the world.

TABLE VII.—EXPORTS OF CEMENT, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1902	340,821	$526,471	1.3	1911	3,135,409	4,632,215	3.9
1903	285,463	433,984	0.95	1912	4,215,532	6,160,341	5.1
1904	774,940	1,104,086	2.4	1913	2,964,358	4,270,666	3.2
1905	897,686	1,387,906	2.2	1914	2,140,197	3,088,809	2.4
1906	583,299	944,886	1.1	1915	2,565,031	3,361,451	3.0
1907	900,550	1,450,841	1.7	1916	2,563,976	3,828,231	2.7
1908	846,528	1,249,229	1.6	1917	2,586,215	5,328,536	2.8
1909	1,056,922	1,417,534	1.6	1918	2,252,446	5,912,166	3.2
1910	2,475,957	3,477,981	3.2				

Scientific Development

No change in the specifications for Portland cement was made during the year 1918 and the matter is still under consideration by the various committees having to deal therewith.

The scarcity of coal and the advance in price had a marked influence upon methods for economies in fuel consumption, not only in the matter of kilns, but in boiler installations. In this field the cement manufacturers coöperated very actively with the Government in all methods of fuel economy, and during the year important steps were taken toward full investigation of the subject of waste-heat boilers using the high-temperature kiln gases for fuel instead of coal, and in the substitution in many cases of electrical for shaft-driven machinery.

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Potash-recovery plants have been installed in many of the mills and the cement industry produced 11,739 tons as against 13,582 tons in 1917, representing 1429 tons of available potash as against 1621 tons for 1917. The close of the year 1918 and the cessation of hostilities found the American market overstocked with potash, due to the many new sources of supply opened up in war time, but economies in dust saving and the abatement of the dust nuisance in the cement industry are likely to enable the manufacture of potash to be a permanent addition to the income of cement manufacturers.

Important papers by Professor Abrams of the Lewis Institute, Chicago, and Professor Talbot of the University of Illinois on concrete and its proper proportioning were among the additions to the scientific literature on cement during the year 1918, as were also papers by N. C. Johnson demonstrating, by moving pictures, the average mixing and proportioning of concrete.

Concrete Roads.—The necessity of good roads was thoroughly demonstrated during the war, with the result that many of the states as well as the United States Government itself have made large appropriations for concrete and other forms of permanent roads. These appropriations run to nearly one-half billion dollars and represent roads scattered in many parts of the country. The motor truck, and especially the long trains of motor trucks operated for Government purposes on the roads of the country, have destroyed many of the old highways, and have shown conclusively that for permanence the concrete road, or at least, a road having a solid and substantial concrete base, is one of the essentials for the successful use of highways for heavy transportation.

Concrete Ships.—Owing to the acute crisis in transportation facilities between this country and Europe at the close of the year 1917 and the early part of 1918, there was a marked increase in concrete shipbuilding. Under the Concrete Ship Division of the United States Shipping Board, Emergency Fleet Corporation, there were authorized concrete ships, barges and other concrete vessels having a total dead-weight tonnage of nearly 800,000. The work was under the direction of Mr. R. J. Wig, chief engineer of the Concrete Ship Section. Under an appropriation of $50,000,000 granted for concrete ships, the Emergency Fleet Corporation had under contract 42 vessels. There were established 5 yards with 4 ways each and 8 ships were ordered for each yard. Some of them were to be 7500-ton tankers and others 7500-ton cargo ships, and in addition to this two 3500-ton vessels were also contracted for. The 42 concrete ships were estimated to have a total tonnage of 298,500 dead-weight. In addition to these, contracts were also let for 50 concrete barges, 100 concrete oil-carrying barges, and a large number of concrete

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tugs. With the advent of peace, many of these vessels were countermanded, but the successful voyages of the steamship "Faith," demonstrating as they did the availability of concrete as shipbuilding material, is likely to cause a very large use of the material.

The percentage of carrying capacity to weight (full-load displacement) of concrete vessels constructed under the ordinary method was 52 per cent. dead-weight to full-load displacement; for wooden vessels it was 53 per cent. and for steel 68.6 per cent. In order to overcome this discrepancy in ratio of carrying capacity to weight, the lower cost of the concrete vessel must necessarily be taken into consideration. Further than this, the engineers during the year developed a new concrete material which reduces the weight very considerably and thus increases the carrying capacity. The ordinary concrete, according to the Government specification, is calculated at 150 lb. per cu. ft., but with the new concrete aggregate known as "puffed brick," the weight is reduced to 106 lb. per cu. ft., and in some cases to even less. The material is a clay, similar to that used in making bricks, but is treated like popcorn and some of the ready-to-eat breakfast foods by being subjected to intense heat which puffs it up. The aggregate thus prepared is then broken into pieces and substituted for the ordinary concrete stone. This new material is not only likely to cause a great revolution in concrete shipbuilding, but will also be available for ordinary building construction, where the carrying load will be largely reduced.

The World Markets

Canada.—The figures for the year 1918 show a decrease of 1,569,595 bbl. compared with 1917. The decrease was 31.47 per cent., as compared with the decrease in the United States of 23.4 per cent. The figures for production for 1917 and 1918 were 4,987,255 bbl. in 1917 and 3,417,660 bbl. in 1918. The barrel of cement in Canada weighs 350 lb. as against 376 lb., the weight of the American Portland cement barrel. The tables of Canadian statistics follow:

PRODUCTION AND SALES OF PORTLAND CEMENT (a)

	1914.	1915.	1916.	1917.	1918.
	Bbl.	Bbl.	Bbl.	Bbl.	Bbl.
Portland cement sold or used	7,172,480	5,681,032	5,369,560	4,768,488	3,591,481
Portland cement manufactured	8,727,269	5,153,763	4,753,033	4,987,255	3,417,660
Stock on hand Jan. 1	1,073,328	2,620,022	2,061,756	2,281,756	1,660,406
Stock on hand Dec. 31	2,628,117	2,062,961	1,444,876	7,664,876	1,480,565
Value of cement sold or used	$9,187,924	$6,977,024	$6,547,728	$7,724,246	$7,076,503
Wages paid	$2,271,006	$1,180,882	$1,307,222	.....	.....
Men employed	2,977	1,679	1,696	.....	.....

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CONSUMPTION OF PORTLAND CEMENT (a)

Calendar Year.	Canadian.		Imported.		Total.
	Barrels.	Per Cent.	Barrels.	Per Cent.	Barrels.
1912	7,132,732	83.3	1,434,413	16.7	8,567,145
1913	8,658,805	97.1	254,093	2.9	8,912,988
1914	7,172,480	98.7	98,022	1.3	7,270,502
1915	5,681,032	99.5	28,190	0.5	5,709,222
1916	5,369,560	99.6	20,596	0.4	5,390,156
1917	4,768,488	99.8	8,580	0.2	4,777,068
1918	3,597,501	99.8	5,913	0.2	3,603,414

(a) Reports of the Mines Branch, Department of Mines, Canada.

The recovery of potash in cement plants in Canada is being investigated by request of the War Trade Board.

England.—The manufacture of Portland cement in England has been limited by war conditions and the output was largely consumed in war work, exports being limited by scarcity of shipping and the submarine warfare. With the end of the war many developments of importance in manufacture and of coöperative methods in scientific development are under consideration.

Australia.—The local cement works in Australia and New Zealand have been busy, and in Australia as well as in South Africa there has been little or no cement received by import. The difficulty of obtaining ship room has exercised a remarkable influence in holding back exports of heavy materials to these far-off countries, with the result that in South Africa and in Australia the local cement works have had their hands full and are making an increase in output.

Germany.—Figures from Germany show that all cement production was regulated by the Imperial Cement Board, and that by degrees the price was advanced until at the close of the war figures as high as $36.00 per ton (over $7.00 per bbl.) were charged by the manufacturers, and in consequence of the constant increase in the cost of production, the cement makers had been compelled to ask for even further advances in sales prices.

As bearing on the financial situation of the cement works, some figures have been issued regarding the activity of the 60 companies in 1917. It is stated that out of this number 14 were unable to declare any dividend, 8 companies paid from 1 to 5 per cent., 32 from 6 to 10 per cent., and 6 companies up to 15 per cent. The figures for the preceding years, dealing with a varying number of companies, have been:

1911—21 works paid no dividend, 23 works distributed over 6 per cent.; 1912—14 works paid no dividend, 35 works distributed over 6 per cent.; 1913—9 works paid no dividend, 37 works distributed over 6

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per cent.; 1914—30 works paid no dividend, 14 works distributed over 6 per cent.; 1915—41 works paid no dividend, 3 works distributed over 6 per cent.; 1916—40 works paid no dividend, 12 works distributed over 6 per cent. The quantity of cement sold in the course of 1918 has decreased in general, the reduction in the case of the South German Syndicate having been 50 per cent., as compared with the equivalent period in 1917.

Norway.—New works are talked of for this country, with a capacity of 300,000 bbl. per annum. These are in addition to the three factories already in existence, with a capacity of 2,000,000 bbl. a year.

France.—France produced before the war about 7,000,000 bbl. of Portland cement. At the close of 1918 practically all plants were largely engaged upon war work. In some cases, American workmen brought over by the American military administration were used in some of the French works to increase production, owing to the number of French workmen who had gone to the war. The price prevailing in 1918 in the largest cement district in France was $26.00 per ton on the cars in bulk, or $5.20 per barrel. There was an enormous decrease in the industrial production during the war, but since the signing of the armistice there has been a gradual resumption of activity and exports are beginning to move to some of the French colonies.

South America.—The figures from the various countries in South America show decreased imports, especially from Europe, as heavy cargo space was entirely out of the question during the war period. From the United States, Cuba took last year 530,642 bbl., while Argentine in 9 months in 1918 took 193,701 barrels. Both Cuba and Argentine have cement plants largely owned by American capital, the Argentine plant having recently got under way and secured advantageous freight rates from the Argentine Railroad both on its outbound cement and incoming coal.

Brazil took 191,850 bbl. of American Portland cement in 1918, while Panama, which was formerly a large consumer in Canal construction days, took 149,782 barrels. Mexico is growing as a consumer of American cement, shipments to that country having increased from 96,015 bbl. in 1916 to 103,859 bbl. in 1918. Peru's imports from this country were 78,114 bbl. in 1918.

A new cement plant has been recently completed at Bello-Horizonte, the capital city of the State of Minas Geraes, Brazil. At this plant it is alleged that a newly invented wood-burning kiln will enable economical manufacture.

South American business like that of other foreign countries was retarded last year by lack of ship room and also by lack of capital, which

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owing to the European war it was almost impossible to obtain. The same condition applies to the West Indies, outside of Cuba, where the use of cement was very limited.

Uruguay's sole cement factory dominated the local market in 1918, owing to the lack of imports.

China.—The Chee Hsin Cement Co. controls the cement business of North China and ships largely to Java and the Philippine Islands. Other leading cement works in China are located in Hupeh Province on the Yangtze, at Hongkong and at Haiphong. There is a Japanese cement works at Dalny. The business of China is given as between 500,000 and 600,000 bbl. per annum.

Japan.—Since 1916 the number of cement factories has remained the same and the number of employees has not increased in anything like the same proportion as the production. This has been due to the introduction of revolving kilns and labor-saving machinery. So great was the effect of these inventions on the production that the industry has recently been suffering from over-production. The 1918 estimate for output is almost 7,000,000 barrels. When it is realized that the domestic demand did not exceed 3,800,000 bbl. in 1916 and 4,500,000 bbl. in 1917, the effect of the war in broadening Japan's market for this product, especially in the Far East, is more readily appreciated. But although the exports increased perceptibly from 74,885,000 kin (1⅓ lb.) in 1914 to 200,583,501 kin in 1915, they have since gradually decreased as the situation became more normal, and 193,429,153 kin was exported in 1916, while only 150,660,500 kin was sent abroad in 1917. This represents only about 500,000 bbl., so that unless a big increase in export takes place in 1918 the cement market in Japan is likely to be badly overstocked.

Another interesting feature of the situation is the great jump in cost of production in 1916. From an average cost of 3.60 yen (1 yen = $0.498) per bbl. in 1913, there was a fall to 3.10 yen in 1914 and a further drop to 2.94 yen in 1915. In 1916 the cost jumped to 4.20 yen; needless to say the price followed this cost and has been steady at 8.50 yen per barrel during 1918.

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CHROMIUM

By Samuel H. Dolbear

The first eight months of 1918 was a period of intensive production and demand in the chromite industry. Early in the year the War Industries Board faced a shortage in this mineral, and the Shipping Board announced that it could not longer supply ships for importations. This placed the development of domestic sources on a mandatory basis and the War Industries Board announced that it was not willing to permit deposits to remain idle if they could be made to produce.

This policy was also applied to others of the so-called "war minerals" and resulted in the introduction and passage of a Mineral Control bill. The act was not made law until Oct. 5, 1918, and was not made operative. A complete embargo against importations by water was announced in April, 1918.

Domestic production increased to 82,350 tons, the largest amount ever recorded. The value per ton was also higher than in any previous year.

Early in the year prices paid for ore from Pacific Coast mines averaged about $1.00 per unit of 1-per cent. chromic oxide on cars at the point of shipment.

At the instance of the War Industries and Shipping Boards, a semi-official basic price of $1.25 per unit for ore containing 38 per cent. chromic oxide was fixed in the latter part of April, 1918. This figure was announced on the Pacific Coast by the California Chrome Co., a subsidiary of the Electro-Metallurgical Co. of Niagara Falls. The latter concern is one of the largest consumers and is a manufacturer of ferrochromium. The announcement also stated that the increased price would remain constant during 1918 and that contracts could be freely had for ore produced during the remainder of the year.

On July 31, however, the company undertook a policy of retrenchment and within 60 days had withdrawn from the market. This action was due to the unexpected amount of imports which, by one pretext or another, had escaped the embargo. These imports in 1918 were 100,142 long tons, of which 80,000 tons was brought in by water. The remainder was produced in Canada and imported by rail.

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CHROMIC IRON IMPORTED INTO THE UNITED STATES, 1914-1918, IN LONG TONS (a)

	1914.	1915.	1916.	1917.	1918.
Cuba	.....	.....	34	17	.....
Canada	533	10,087	12,220	19,012	20,142
England	58	2	5	5	.....
Greece	8,155	4,305	7,900	.....	.....
Japan	.....	.....	.....	.....	.....
French Oceania	30,860	28,031	(b)30,950	10,300	.....
Australia	.....	.....	(b) 2,968	.....	.....
British South Africa	.....	22,800	(c)23,000	4,750	.....
Portuguese Africa	23,200	11,230	(c)38,850	37,800	.....
Turkey in Asia	11,880	.....	.....	.....	.....
Guatemala	.....	.....	.....	179	.....
Total	74,686	76,455	115,945	72,063	(d)100,142

(a) Statistics furnished by the Department of Commerce, Bureau of Foreign and Domestic Commerce. (b) E. J. Lavino & Co. importers, credit New Caledonia with all that listed above under French Oceania and Australia, amounting to 33,936 long tons. (c) E. J. Lavino & Co., importers, credit Rhodesia with all that listed above under British South Africa, amounting to 61,850 long tons (J. S. Diller, U. S. Geol. Surv. *Bull.* 666-A.) (d) Includes New Caledonia, Rhodesia, Brazil, and other smaller producing countries.

The quantity and value of imports of chrome yellow or green are given in the following table:

Year.	Quantity, Pounds.	Value.
1911	156,586	$25,029
1912	156,733	25,516
1913	161,153	24,731
1914	154,933	24,922
1915	48,303	9,492
1916	29,495	6,099
1917	18,536	2,420
1918	37	10

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Ore.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		Pounds.		Long Tons.		
1911	22,408	$2,159	6,789	$1,349	37,540	$407,958	$411,466
1912	32,913	3,085	8,728	1,376	53,929	499,818	504,279
1913	18,629	1,819	5,562	1,100	65,180	622,821	625,740
1914	31,858	2,375	9,164	1,597	74,686	655,306	659,278
1915	32,942	2,902	3,571	755	76,455	780,061	783,718
1916	459	75	*Nil.*	*Nil.*	115,886	1,548,402	1,548,477
1917	2,404	962	*Nil.*	*Nil.*	72,063	1,110,659	1,111,621
1918	20	8	9,512	1,857	100,142	2,891,725	2,893,590

(a) Bureau of Foreign and Domestic Commerce.

During the last quarter no open market for ore existed. Producers who had contracts for future deliveries were able to continue operations until the end of the year, when the few remaining contracts for 1919 output were canceled.

The Mineral Control bill enacted by Congress anticipated the maintenance of a market for domestic production for two years after the declaration of peace. In many cases preparations had been made for this by

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the erection of concentrating plants, construction of expensive roads, etc., the cost of which could not be recovered in a shorter period.

The failure of the domestic market was not due to the cessation of the war. It was due to large importations and the failure to make the Mineral Control bill operative.

Restrictions prohibiting the use of better grades of ore for refractory purposes were enforced from May until the latter part of the year. This limitation was at first placed at 38 per cent. and later raised to 43 per cent.

Until after the armistice had been signed, the consumption of ferrochromium was limited to use for Government purposes.

The Ferro-Alloy Co. of Denver, Colo., commenced the manufacture of ferrochromium, but in spite of the apparent demand, was unable to sell its product. The Pacific Electro-Metallurgical Co. of San Francisco erected a ferro-alloy plant at Bay Point, Calif., to produce ferrochromium and ferromanganese, but limited its efforts to the latter.

The following table of production shows the influence of the war on domestic production of chromite.

Year.	Quantity, (Long Tons).	Value.
1908	359	7,230
1909	598	8,300
1910	205	2,729
1911	120	1,629
1912	201	2,753
1913	255	2,854
1914	591	8,715
1915	3,281	36,744
1916	47,035	726,243
1917	43,725	1,049,400
1918	82,350	3,937,991

The normal consumption of chrome during pre-war years was 66,000 tons.

Mining and Production of Chromite by Countries

United States.—In the United States, the yield, 79,000 long tons, was much greater than in any former year. California was the chief source of chrome ore as in other years, its mines producing 56,200 tons and Oregon 22,500 tons. The remainder came from Maryland, North Carolina, Pennsylvania, Washington, Wyoming and Alaska. No shipments of chrome ore from Montana were reported.

Although there were about 700 owners of domestic chrome deposits in 1918, only about 270 actually shipped and marketed their output.

Unsold stocks in the hands of the miners at the close of 1918 are reported to the U. S. Geological Survey at 46,000 short tons.

The larger part of the California output came from Del Norte, Siskiyou, Shasta, Tehama, Calaveras, Lake, Placer, Eldorado, Tuolumne,

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Fresno and San Luis Obispo counties. Many concentrating plants were put into operation and construction of a number of others was under way when the market broke. In Oregon, which ranked second to California, Curry, Josephine, Jackson, Coos and Douglas counties in southwestern Oregon and Grant, Baker, Umatila and Malheur counties in eastern Oregon were the chief producting counties.

Several cargoes were shipped from Alaska and the deposits near Juneau were equipped for concentration.

THE PRINCIPAL SUPPLIES OF CHROME ORE (a)
(In metric tons)

	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Brasil	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bosnia	332	320	250	200	305	533	.....	.....	.....	.....
Canada	2,470	279	143	.....	.....	123	11,196	24,963	32,978	19,953
Cuba	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Greece	9,600	9,463	4,615	6,468	6,342	7,059	10,420	9,880	.....	.....
Guatemala	.....	.....	.....	.....	.....	.....	.....	.....	2,000	(c)2,500
India	9,398	1,765	3,864	2,936	5,670	5,986	3,828	20,484	27,497	.....
Japan	.....	2,091	1,500	.....	.....	2,108	2,979	8,280	8,939	(c)2,400
New Caledonia (b)	40,000	40,000	82,806	51,516	63,370	42,000	67,000	74,115	41,892	.....
Queensland	.....	.....	.....	.....	.....	.....	.....	.....	768	236
Rhodesia	37,024	40,000	47,600	62,850	63,384	49,009	61,590	80,624	74,133	31,777
Russia	22,213	1,362	1,238	21,277	.....	.....	.....	.....	.....	.....
Turkey	11,364	.....	.....	.....	.....	.....	.....	.....	.....	.....
United States	606	208	122	204	259	601	3,336	47,791	44,429	83,676

(a) From the official reports of the respective countries. (b) Exports, except 1909, 1910, 1914 and 1915. (c) Estimated.

Canada.—The yield from Canadian chrome mines during 1918 was 21,994 short tons valued at $867,122, as compared with 23,327 short tons valued at $572,115 in 1917. With the exception of 2000 tons the 1918 production was sold in the United States.

No new deposits were discovered during the year. The largest operations were the Belanger enterprise and the Mutual Chemical Co. Both operated concentrating mills, although they produced some shipping ore as well.

The Quebec Asbestos and Chrome Co. at Saint Cyr, near Richmond, and the Black Lake Asbestos and Chrome Co. both worked their mines to capacity during the year.

The Canadian mines expect to continue production during 1919.

Cuba.—An investigation of the Cuban chrome deposits was made by Albert Burch for the U. S. Bureau of Mines and E. F. Burchard for the U. S. Geological Survey early in 1918. As a result production was commenced, the principal operation being that of a subsidiary of the Bethlehem Steel Co. Several cargoes have been shipped.

All the deposits of chrome ore in Cuba that have thus far attracted attention are within 25 miles and most of them within 10 miles of the north coast. There are about twelve groups of deposits, which display

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considerable diversity in quality, size, and accessibility. One of the most westerly deposits is in the eastern part of the Province of Havana, and two are in the Province of Matanzas. The next group toward the east is in the Province of Camaguey, a few miles northeast of the City of Camaguey. Other groups of deposits are in the Province of Oriente, one near Holguin and another south of Nipe Bay, and there are three groups in the mountains near the coast between Punta Gorda and Baracoa.

New Caledonia.—The mines of this country are large and are cheaply worked with French convict labor. They are equaled in size only by the Rhodesian mines. Much of the 1918 production was first shipped to Australian ports and later reloaded into ships bound for the United States.

Rhodesia.—Chromite production in Rhodesia fell from 72,962 long tons in 1917 to 31,275 long tons in 1918. Much of this decrease was due to lack of ships for exportations. The discovery of a deposit larger than anything heretofore developed in any country has been announced. The ore occurs in an area of 4500 acres in the Umvuknes Range. It is claimed that a careful survey has proved the existence of 2,000,000 tons of ore and that an average of 300 samples shows 53 per cent. chromic oxide. The deposits are 30 miles from rail. If a branch railroad were constructed to connect with the main line at Blanket Junction, it is estimated that the cost of ore delivered at Biera would be low.

Guatemala.—Chromite was first discovered in Guatemala in 1915. The ore is high grade, averaging over 50 per cent. chromic oxide. In 1918 the production was reported at 2500 tons, all of which was exported to the United States.

Mexico.—Within the last 3 years an exceptionally pure chromite ore containing 54 per cent. chromic oxide (Cr_2O_3-Fe_2O_3) was discovered in the Department of Progreso. About 600 tons of this ore was shipped to the United States by the Mina Loreto.

Early in 1918, other deposits of chromite were found in the Department of Jalapa, which at present are being worked by the International Railways. They have been shipping approximately 500 tons a month to New York. This chromium field extends over an area 15 miles square. Mining is being done by hand labor, and only a hand-picked product exported. Zones of low-grade ore in the neighborhood, not being worked at present because of high cost, may prove a valuable asset in the future when machinery is installed.

The Loreto Mines are 4 miles and the Jalapa Mines 10 miles from the Railroad.

Japan.—The production of chromic iron ore in Japan for the first half of 1918 was 1173 long tons, which indicates a 75-per cent. reduction

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in the 1918 output compared with that of 1917. The output in 1917 was 8798 long tons. These figures were compiled from the monthly reports of the Japanese Bureau of Mines. The great reduction is doubtless due wholly to the embargo on imports into the United States.

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COAL AND COKE

By Frank H. Kneeland

The year 1918 proved conclusively that in time of crisis the ability of American mines to produce fuel is greater than the ability of our industries to consume it. Even though the signing of the armistice decreased production before the end of the year, the total production was 33,308,000 tons above the 1917 figure. The total for the year, according to the U. S. Geological Survey, was 684,710,000 short tons. Anthracite production was 98,826,084 short tons, or 785,727 tons less than in 1917. Bituminous production was 585,883,000 tons, or 34,093,000 tons more than in 1917. By-product coke increased 3,558,300 tons, while beehive coke decreased 2,686,756 tons. Following the signing of the armistice in November the coal output decreased materially, the production in December reaching the lowest total for any month of the year.

The country may look with satisfaction upon the record that was made in the emergency that existed. The stocks of coal in November were nearly three times as great as those that were in yards one year previously. Since bituminous coal is a product that cannot be satisfactorily stored for long periods, the natural outcome of the situation was for the mines in most districts to curtail production. Only in this way could the large stocks of coal on hand in industrial yards be used up and normal conditions in the coal trade be resumed.

A backward look at the history of coal mining shows that only three times did it require an interval of two years for production to come back and exceed the last peak that was established. It is certain that the coal output in 1919 will be less than it was in 1918, for during the early months of this year the Nation was going through a serious time of reconstruction. More than 10,000,000 tons of coal was promptly released by the cancellation of war work in powder, airplane and small-arms plants. The navy consumption will be 4,000,000 tons less this year. The railroads have effected plans that should save upward of 8,000,000 tons during 1919. Conservation measures that were forced on industries by the needs of the war will bear fruit during the coming months and bring about other material savings.

Coal is produced in the United States to meet the requirements of industry and the domestic and public needs of the people of this country and Canada—not more than 1 per cent. of the output leaves the shores

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of North America. The needs of industry currently supplied, the mines have no choice but to stop, for, excepting by the larger anthracite companies, coal is not stored by the producer. Unless for protection against a real or imaginary future inability to obtain fuel, the consumer does not invest in abnormally large storage piles of coal.

The production of all kinds of bituminous coal in 1918 was ample for all needs. Despite the inroads of the influenza epidemic among mine workers and railroad employees, it would easily have been possible in November and December to have produced and transported 100,000,000 instead of 85,000,000 tons, and the year's total would have reached the coveted 600,000,000 mark. But the country did not need the coal. Even before Nov. 11, when word came that no more guns and shells or new plants for making these engines of destruction were needed, it was evident that the Fuel Administration's estimate of 623,000,000 tons from April to April would not be required; that, having seen that the coal mines and the railroads could get the coal into their stock piles, consumers were fast losing their anxiety.

PRODUCTION OF COAL IN THE UNITED STATES IN SHORT TONS.

State.	1916.		1917.		1918.
	Quantity.	Total Value.	Quantity.	Total Value.	Quantity(e)
Alabama	18,086,197	$24,859,831	20,068,074	$45,616,992	21,280,000
Alaska	13,073	52,317	53,955	265,317	70,000
Arkansas	1,994,915	3,836,845	2,143,579	5,492,777	2,228,000
California and Idaho	7,240	15,367	6,423	14,791	6,000
Colorado	10,484,227	16,964,104	12,483,336	27,669,129	12,485,000
Georgia	173,554	310,093	119,028	301,391	101,000
Illinois	66,195,336	82,457,954	86,199,387	162,281,822	91,263,000
Indiana	20,093,528	25,507,246	26,539,329	52,940,106	27,325,000
Iowa	7,260,800	13,530,383	8,965,830	21,096,408	8,240,000
Kansas	6,881,455	12,252,723	7,184,975	16,618,277	7,292,000
Kentucky	25,393,997	30,193,047	27,807,971	60,297,653	29,690,000
Maryland	4,460,046	6,947,623	4,745,924	11,667,852	4,759,000
Michigan	1,180,360	2,653,182	1,374,805	4,426,314	1,385,000
Missouri	4,742,146	9,044,505	5,670,549	13,755,864	5,605,000
Montana	3,632,527	6,286,197	4,226,689	8,919,136	4,276,000
New Mexico	3,793,011	5,580,369	4,000,527	7,455,166	4,241,000
North Dakota	644,912	946,082	790,548	1,425,750	813,000
Ohio	34,728,219	40,150,907	40,748,734	100,897,148	46,464,000
Oklahoma	3,608,011	7,525,427	4,386,844	12,335,413	4,785,000
Oregon	42,592	113,976	28,327	95,663	39,000
Pennsylvania, bituminous	170,295,423	221,685,175	172,448,142	421,268,808	183,712,000
South Dakota	8,886	18,021	8,042	23,346	7,000
Tennessee	6,137,449	7,522,445	6,194,221	13,592,998	6,916,000
Texas	1,987,503	3,092,663	2,355,815	4,177,608	2,260,000
Utah	3,567,428	5,795,944	4,125,230	8,531,382	5,535,000
Virginia	9,707,474	10,261,424	10,087,091	20,125,713	10,100,000
Washington	3,038,588	6,907,428	4,009,902	10,727,362	4,056,000
West Virginia	86,460,127	102,366,092	86,441,667	200,659,368	91,350,000
Wyoming	7,910,647	12,239,707	8,575,619	16,593,283	9,600,000
Total bituminous	502,519,682	665,116,077	551,790,563	1,249,272,837	626,332,000
Pennsylvania, anthracite	87,578 493	202,009,561	99,611,811	283,650,723	98,826,000
Grand total	590,098,175	867,125,628	651,402,374	1,532,923,560	725,158,000

(e) Estimated.

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In the 6 months from May 1 to Oct. 30, 1918, 319,000,000 net tons of bituminous coal was produced, 6 months in which the lowest monthly output was only slightly less than 51,000,000 tons and the highest more than 55,700,000 tons. At this rate 600,000,000 was easy and 624,000,000 not out of reason. The results, by months, for 1917 and 1918 are given in the following table; from January, 1915, to December, 1918, results are shown graphically in the diagram (Fig. 1).

PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES IN 1917, WITH ESTIMATES FOR 1918, BY MONTHS, IN NET TONS

	1917	1918
January	47,967,354	42,607,000
February	41,352,711	44,385,000
March	47,868,652	48,631,000
April	41,854,320	46,591,000
May	47,086,452	50,927,000
June	46,824,646	51,758,000
July	46,291,572	55,587,000
August	47,372,226	55,732,000
September	45,107,956	51,757,000
October	48,337,726	52,885,000
November	47,689,801	44,393,000
December	44,037,147	40,630,000
Totals	551,790,563	585,883,000

Demand for coal did not take an upward turn, following the depression of 1914, until late in 1915, and then was sustained through 1916 only in

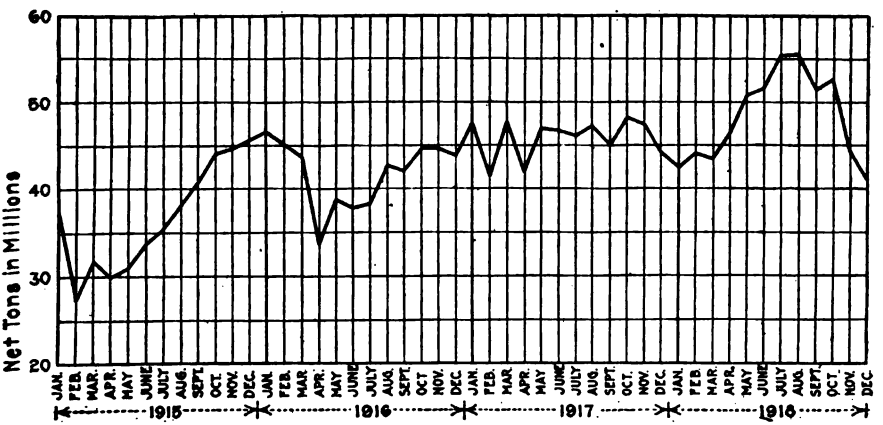

FIG. 1.—United States production of bituminous coal, 1915–18, by months.

the eastern-most sections of the country. During the summer of 1916, while the mines in the Pittsburgh district were running full time, those in Illinois were suffering from their usual warm-weather idleness because, by operating one, two or three days a week, all the coal anyone wanted in the latter State was supplied.

From October, 1916, to October, 1918, there were few dull moments in the coal business anywhere in the United States. Demand for coal

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to run the factories in the East that had sold munitions to Europe became, in the winter of 1916–1917, more than the normal facilities could send forward, and Ohio and even Illinois coal was shipped to New England.

The mines that were to supply this intensified manufacturing activity along the North-Atlantic seaboard and as far west as the northeastern section of Ohio are in the four States of Pennsylvania, West Virginia, Maryland and Virginia, states from which, in 1916, came more than 54 per cent. of the bituminous output of the country and 60 per cent. of the total including anthracite. And in 1917, with the greatest need for coal ever faced in this country (up to that time), a demand that fell heaviest in this section, this group of states—tributary to the North-Atlantic seaboard—produced but 1 per cent. more than in 1916; the group gained but 2,800,000 tons, while the other coal fields added more than 46,000,000 tons to their records.

Ohio and eastern Kentucky, with markets mainly west and north, gained 6,244,000 tons, or 12 per cent., in 1917; Illinois, Indiana and western Kentucky, shipping in all directions, from Canada to the gulf and Nebraska to the Hudson, increased nearly 29,000,000 tons, or 31 per cent. There was nothing phenomenal in the record increase of these fields; a steady market permitted the operation of the mines in summer as well as in winter, something new for Illinois.

West of the Mississippi the fields from North Dakota to Texas gained 4,388,000 tons, or 16 per cent.; the Rocky Mountain fields 4,023,000 tons, or 14 per cent., and Washington 971,000 tons, or 32 per cent. In the south, Tennessee, because of strikes in the summer of 1917, made no progress; but Alabama gained 1,982,000 tons, or 11 per cent.

The early estimates for 1918 are not much changed in the final figures, and may be compared with the previous years. The most important group, that including Pennsylvania and West Virginia, from which comes the major portion of our high-grade coal, gained 16,200,000 tons, or 6 per cent. Eastern Kentucky, Ohio and Michigan gained 6,925,000 tons, or 11.6 per cent., about the same as the increase of 1917 over 1916. Tennessee increased 12 per cent. and Alabama 6 per cent. Illinois, Indiana and western Kentucky gained but 6,533,000 tons, or 5 per cent., against nearly 29,000,000 tons, or 31 per cent., in 1917. In the middle west the group comprising North Dakota, Iowa, the Southwestern States and Texas had a slight decrease—276,000 tons, or 1 per cent., compared with a gain of 4,388,000 tons, or 16 per cent., the year previous. The Rocky Mountain States increased 2,726,000 tons, or 8 per cent., nearly equal to the gain of 1917 over 1916. Washington, with a gain of 32 per cent. in

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1917, increased but 1 per cent. in 1918. The distribution of the increases in 1917 and in 1918 are shown in the map (Fig. 2).

The coal fields of Pennsylvania, Maryland, West Virginia and Virginia, from which comes the supply of bituminous coal for the northeast section of the United States, also furnish the greater part of the tidewater supply for steamship bunkers, for the navy and for foreign export. They also ship high-grade coal, both low and high volatile, west by rail and by the lakes.

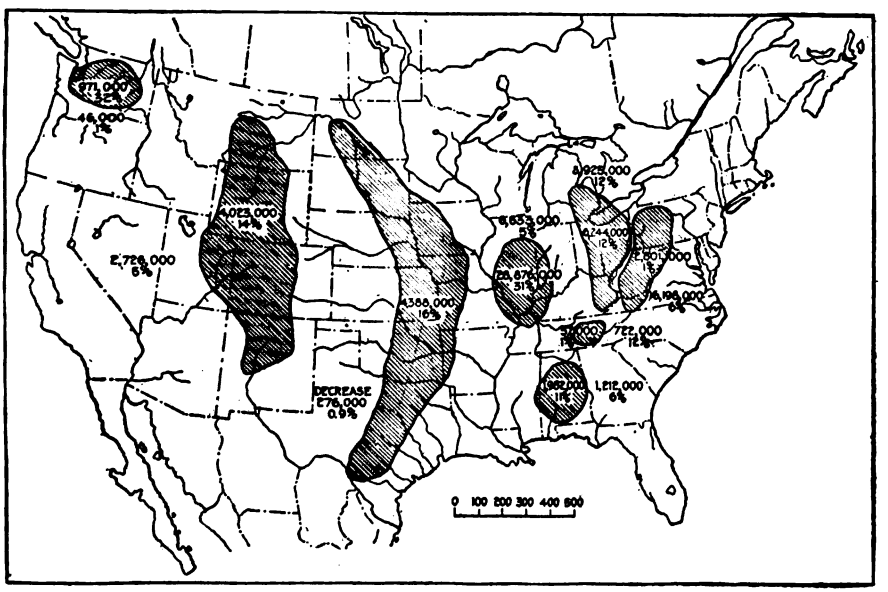

FIG. 2.—Distribution of the increase in production of bituminous coal. Figures in the shaded areas are increases for 1917 over 1916; those outside for 1918 over 1917.

Lake cargo shipments from these states in 1918 were 16,506,000 tons, a decrease of 2,000,000 tons, compared with 18,453,000 tons in 1917. Deliveries at tidewater in 1918 were 37,489,000 tons against 31,181,000 tons in 1917, a gain of 6,300,000 tons, of which, however, 1,400,000 represented increased shipments to New England by water. All-rail shipments west beyond Ohio increased 2,700,000 tons, and all-rail and Lake Ontario deliveries to Canada, 1,300,000 tons. The net result was that, of the 16,200,000 tons increased production in these states, approximately 10,000,000 tons was available for consumption by all consumers, including the railroads, in the State of Virginia and north and east of the Pennsylvania-Ohio stateline.

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This increase of around 10,000,000 tons was accumulated after Apr. 1 to meet an expected increase in demand of less than 17,000,000 tons in the twelve months beginning with April. In other words, the northeast section of the United States, the sore spot on the map all through 1917 and early in 1918 has been taken care of this year.

The coal fields supplying the section around the lower lakes had increases in production in 1918 that have nearly equaled the expected gain in requirements. New high records in the movement of lake coal and rail shipments from Illinois to the Northwest fully met the increased demands in that section. In the South the anticipated need for an additional 7,000,000 tons did not materialize.

The iron and steel industry, which reached its maximum speed under the conditions obtaining in 1918, consumes in round numbers one-third of the coal used by industrials and public utilities. A study of the reports of fuel consumption by 142 of the larger steel plants shows an increase of 18 per cent. in the average weekly consumption of steam and gas coal (exclusive of that used in making coke) in 1917 over 1916, and an increase of but 3 per cent. in 1918 over 1917. These plants had 54 per cent. more coal on hand Oct. 1, 1918, than on the same date in 1917.

By the summer of 1918 the United States had about reached the upper limit in ability to consume coal, and had the war progressed the ability to consume would have been reached long before the limit of ability to produce.

Viewed from a distance the progress of the coal industry has been continuously upward, but at close range it is seen to have had many fluctuations. In the past 38 years, or since 1880, there have been seven "peaks" in the curve of bituminous production—in 1884, 1887, 1893, 1903, 1907, 1910 and 1913, with the expectation that 1918 represents the eighth peak. In the case of four of the seven depressions following these peaks, but one year was required for the "comeback"; but following 1884, 1907 and 1913, two years elapsed before new high records were established. The records for the past 18 years show but one instance where production was down for three years in succession. The record of 315,000,000 tons in 1903 was followed by three years of depression, and it was not until 1907 that production exceeded the output in 1903.

The year 1918 was the first year in the history of the industry when Government control was exercised throughout the entire 12 months. As a general rule, however, operators who regarded Federal regulation with fear and trembling approached the return to normal, that is competitive, conditions with the same foreboding. Throughout the entire land a shortage of labor was experienced. Enlistments and draftings into the army and navy had their effect in reducing the operating forces

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of the mines. While no region was exempt, miners from the eastern and western fields were powerfully attracted by the high wages and steady work offered by the munition plants and shipyards. The coal digger, proverbially nomadic in his habits, promptly "pulled up stakes" and sought employment in more promising fields whenever his earnings from fuel production became lower than he thought they should be. Strenuous efforts were exerted by many of the coal companies in an attempt to keep their working forces somewhere near normal and adequate. Car shortage, which has been the great handicap to maximum production in past years, was less felt in 1918 than was anticipated. Because of embargoes and priorities, however, shortages of mining supplies developed in some places. As a rule these were not in the main serious, and they exerted only a minor depressing effect upon production. As to the future, much is uncertain and few in the coal industry are willing to hazard a prediction. It is but natural that the problems of the immediate future, those that effect the destinies of the nation and in fact the entire race, should also possess a powerful influence over the third industry of the land. Most leaders of those engaged in coal production are agreed, however, that the immediate future is bright. The following reports, chiefly from *Coal Age*, in most cases were written by the chief mine inspectors of the various states, and set forth in detail the results of the past year's effort. It is regrettable that the fiscal years of some states do not coincide with the calendar year. This is confusing, and a change to the calendar year would be beneficial to all concerned.

Coal Mining By States

Alabama.[1]—The coal production of Alabama for the year 1918 showed a decrease of 1,500,000 short tons as compared with 1917, notwithstanding that many new mines were opened and all operations ran with fair regularity throughout the entire year. To a certain extent the decrease is attributable to the influenza epidemic that prevailed the greater part of the last 3 months of the year; also to the fact that the mining industry was handicapped by a lack of labor.

The supply of all grades and qualities of coal was unequal to the demands for coking, steam and domestic purposes. Many improvements have been made during the year at different plants, notwithstanding the increased cost of material and the labor shortage.

Alaska.[2]—Probably about 75,000 tons of coal was mined in Alaska during the calender year 1918. Of this amount the Alaskan Engineering Commission, operating leasing units Nos. 7 and 12 in the Matanuska

[1] C. H. Nesbitt, Chief Mine Inspector, Birmingham, Ala., *Coal Age*, Jan. 16, 1919.
[2] Sumner S. Smith, Alaskan Engineering Commission, Eska, Alaska, *Coal Age*, Jan. 16, 1919.

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Field, produced about 60,000 tons. Henry Baxter, manager of the Matanuska Coal Co., produced about 3000 tons early in the spring.

The Chickaloon Coal Co., of which Walter A. Gompertz is manager, ran several thousand feet of tunnels and has now started operations with diamond drills on its lease covering units Nos. 10 and 11 in the Matanuska Field. The Little Susitna Coal Co., operating near the main line of the Government R. R., not far from the Little Susitna River, produced about 2000 tons of coal; and the Cache Creek Dredging Co., operating a dredge on Cache Creek, mined about 5000 tons, which was used to generate electric power for the dredge.

Maitland & McNally, of Anchorage, Alaska, are operating what is known as the Wharf Mine at Bluff Point on Cook Inlet, producing coal for the cannery trade. They probably sold some 5000 tons during the year.

It is reported that the Alaska Coal and Petroleum Co., of Katalla, has mined about 1000 tons from its property on Canyon Creek in the Bering River Field. Operations have also been started on a lease covering a portion of what was the old "English Company" ground at Katalla.

Several thousand tons of coal was mined in the Nenana Field for use in construction work on the Government R. R. Most of this was produced from free-use 10-acre leases by small operators. The balance of the total tonnage was made up entirely from the production from free-use 10-acre permits scattered throughout the territory from Chicken Creek on the Upper Yukon to Candle on the Seward Peninsula. All of the foregoing figures of production are in short tons.

Arkansas.[1]—The coal region of Arkansas covers about 2000 square miles and comprises the six counties of Sebastian, Scott, Franklin, Johnson, Logan and Pope. The production of coal in each of these counties is of commercial importance, but the counties producing the largest amount of coal are Sebastian, Johnson and Franklin. Sebastian County alone produces more than one-half the output of the entire State.

The approximate amount of capital invested in the coal-mining industry is $2,896,600. The production for the fiscal year ending June 30, 1918, was $2,373,687 short tons. The market value of this coal was approximately $7,777,080.

To produce this amount of coal 4425 miners and company men and 394 mules were worked in the mines. The miners used 99,028 kegs of black powder, at a cost to them of $198,056. The mines hoisted coal during 15,725 mine days.

Fourteen fatal and 150 non-fatal accidents occurred during this period. There were 169,549 tons of coal produced for each life lost and 15,824 tons for each non-fatal accident.

[1] Claude Speegle, State Mine Inspector. Fort Smith, Ark., *Coal Age*, Jan. 16, 1919.

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There were 378 office men and mine officials employed, making a grand total of 4803 persons actively engaged in and depending upon the mining industry. The total number of coal mines in the State is 155.

A great number of small mines and five large ones have been opened up in this State within the last year.

Colorado.[1]—During the year 1918 the coal industry of Colorado was confronted with many changes, but no effort was made tending toward stabilizing conditions. Early in the year there were insistent demands for increased production. Coal consumers both in this and the surrcunding states were alarmed by reports of an impending coal famine, and there were strong indications that such a condition might be forthcoming.

Colorado consumes nearly all of her output; in 1917 only 2,634,458 tons was shipped out of the State, but when the system of zoning was was put into effect by the Federal authorities, there was created a greater market outside of the State for Colorado to supply. A great drive for increased production was made, and all the mines worked full time.

On Nov. 1 the production amounted to 10,812,548 tons, an increase of 516,379 tons compared with the same period of 1917, and about one-third of the expected increase. However, instead of a coal famine, there came a slump, which the sudden cessation of the war with the consequent canceling of war orders and closing down of munition plants made more acute. The drop in the production brought the increase of 516,379 tons of the first ten months down to 197,932 tons increase by the end of December.

With wages and the cost of production high, the retail selling prices were correspondingly high; but the wholesale prices per ton at the mines were slightly lower than in 1917.

TOTAL COAL PRODUCTION OF COLORADO BY COUNTIES

Counties	1917.	1918.
Boulder	1,261,621	1,306,099
Delta	103,060	90,657
El Paso	366,920	281,978
Fremont	866,064	899,137
Garfield	108,180	73,171
Gunnison	647,070	647,295
Huerfano	2,355,751	2,665,259
Jackson	86,699	77,405
Jefferson	127,644	120,668
La Plata	136,789	137,420
Las Animas	4,449,743	4 515,684
Mesa	206,734	218,887
Moffat	500	600
Montezuma	998	797
Montrose	1,513	1,036
Pitkin	21,463	29,109
Rio Blanco	4,710	4,604
Rout	1,065,007	1,004,451
Weld	622,658	638,978
Total	12,433,129	12,713,237

Increase, 1918 over 1917	197,932
Average number of men employed in and about the mines, 1918	14,200
Number of days worked per mine, 1918	196
Number of mines in operation, 1918	230

[1] A. E. Tibbits, State Mine Inspector's Office, Denver, Colo., *Coal Age*, Jan. 16, 1919.

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There were no labor troubles other than a scarcity of experienced miners to add to the difficulty of the coal situation. In the northern field there was a moderate demand for the soft coal, resulting in the mines working only half time and cutting down the wages of the men. This prompted many of them to leave the State to seek better paid employment.

There were substantial improvements made at many of the mines in spite of the fact that the cost was extraordinarily high. The welfare of the employees received attention, and in many of the coal camps the living conditions were considerably improved. The rate of fatalities was about 4.7 per thousand men employed. While this is a high death rate, yet considering the preponderance of inexperienced and foreign-born men working at the mines it shows that safeguards to protect life were enforced to an appreciable extent.

Idaho.[1]—The Horseshoe Creek coal field of Teton County, Idaho, is the only portion in the whole State that has so far developed a commercial coal mine. It embraces a portion of the famous coal-bearing formations of Wyoming, which extend for a short distance over the border into Idaho. The Horseshoe coal field is situated on the eastern slope of the Big Hole Mountains, 12 miles due west of Driggs, in Teton County, southeastern Idaho.

These coal deposits have been operated since their discovery in a desultory fashion by the original claim owners and were locally known as the Brown Bear, Boise, Horseshoe and Packsaddle claims. They were held by local people without means to push the development to a point where a large tonnage could be produced. This, in connection with the long wagon-haul of ten miles to the nearest important settlement, kept the output limited strictly to local demands of the nearby agricultural communities.

A typical analysis of several of the seams is as follows: moisture, 63.0 per cent.; volatile, 41.50 per cent.; fixed carbon, 52.60 per cent.; ash, 2.30 per cent.; sulphur, 0.40 per cent.

About 7000 tons of coal was produced in 1918, all from development operations. It is expected that the daily output of the mine will soon be from 200 to 300 tons. After the cross-cut tunnel is in operation it is expected to increase this output to 600 tons per day.

The various coal seams have been tested out and the property thoroughly surveyed and proved by surface work in addition to its 500-ft. slope development. From the data obtained as a result of this work and the uniformity of the seams, for a distance of two miles along their strike, it is conservatively estimated that the coal available above the

[1] Robert N. Bell, State Mine Inspector, Boise, Idaho, *Coal Age*, Jan. 16, 1919.

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level of the long cross-cut tunnel now being driven will be in excess of 130,000,000 tons.

Illinois.[1]—During the year 1918 the coal mines of Illinois probably produced a larger tonnage than ever has been produced in any year of coal mining in this State.

In the year 1917 there were in operation in Illinois 810 mines employing 80,893 men, who produced for the fiscal year ending June 30, 1917, 78,983,527 short tons of coal by working 179 days as an average.

The mines are divided into two classes, shipping and local. The shipping mines, working 215 days and employing 78,056 men, produced 77,412,054 tons. The local mines, working 154 days and employing 2837 men, produced 1,571,473 tons of coal.

On the other hand, in the year 1918 there were in operation 967 mines, employing 91,372 men, and these men produced for the fiscal year ending June 30, 1918, 89,979,469 tons. There was an increase in the number of mines in operation of 157, of which 47 were in the shipping class and 111 in the local class. The increase in the number of mines in operation does not necessarily mean that there are that many new mines; a great many are old mines which were reopened.

The new mines that have been opened are of the large up-to-date kind, equipped with all the latest improved mining appliances. They will in nearly every instance be large producers of coal.

In addition to the increase in the number of mines in operation, the number of men employed also increased to a large extent, notwithstanding the fact that a great many mine workers were overseas.

The figures given below are for shipping mines only, and are nearly correct for the first ten months of the year 1918, with estimates for November and December.

The number of short tons produced was 89,325,962, and there were 88,200 employees, who worked an average of 245 days. These figures, together with the tonnage produced by the local mines, will bring the total above 90,000,000 tons; had the production of July been maintained for the entire year, the production, in round numbers, would have been above 112,000,000 tons.

In addition to the increased production the conditions of the mines of the State have been improved to a marked degree; the coal companies are taking a keen interest in matters of safety, which will surely bring a reduction in the number of mine accidents.

Indiana.[2]—Coal output in the State of Indiana during the fiscal year ending Sept. 30, 1918, broke all records for this State. There was some

[1] Martin Bolt, Assistant Director, Department of Mines and Minerals, Springfield, Ill., *Coal Age*, Jan. 16, 1919.

[2] John Ogilvie, State Mine Inspector, Indianapolis, Ind., *Coal Age*, Jan. 16, 1919.

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time lost on account of the shortage of railroad cars, which was the principal cause of throwing some mines idle more than they otherwise would have been. There were some days lost during the year on account of strikes, but these were few. Owing to the large demand for coal in this country, the miners of Indiana stood loyally behind the Government, laid aside their petty grievances and kept at work while their differences were being adjusted. Some time was lost on account of incendiary fires occurring at several mines. The entire surface plant of two mines was completely destroyed, throwing these mines idle for about 60 days.

The production of coal for the fiscal year was 28,795,682 tons, including block and bituminous coal. This was divided as follows: block coal, 551,184 tons; bituminous coal, 28,244,498 tons. The wages paid by the various coal companies was $39,776,916.19, making an average wage earned per employee of $1424.06 per year.

The total number of mines employing more than ten men in this State is 245, of which 51 are new operations sunk during the fiscal year. This is a large increase of new mines, and everything points to a bigger production of coal in the future.

The American Coal Co. at Bicknell has the largest producing mine, having produced 5900 tons in one day. This company has sunk another new mine, which is being equipped to hoist over 6000 tons per day.

The average number of days that the coal mines were in operation during the year was 254. This is an increase of 30 days over last year.

Steam-shovel mining has become an important factor in the coal-producing industry in this State. These operators maintain an organization known as the Coal Producers' Association, which has twenty-one members, who produced approximately two million tons during the fiscal year ending Sept. 30, 1918. Stripping plants are operated in ten counties in the State.

There are about 300 small mines in the State, and it is estimated that the production of these for the year was 2,500,000 tons. Taking the production from mines coming under the jurisdiction of the State mine inspector, stripping plants and small mines, the State had a total production for the year of 33,295,682 tons.

There were 114 fatalities in and around the mines during the year. The number of tons produced per fatality was 292,067.

Iowa.[1]—Coal-mining conditions in Iowa were good throughout almost all of the year 1918, better, in fact, taken as a whole, than for a number of years past.

In 1918 the mining business was good during the months of January, February and a part of March; then there began to be a slump that may

[1] L. E. Stamm, Secretary, Iowa Mine Inspectors, *Coal Age*, Jan. 16, 1919.

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be traced to two conditions confronting the trade just at that time. The first was the warm weather prevailing in March, which caused a falling off in the commercial coal trade, and the second was that many of the contracts for coal for railroad use expired in March and the roads refused to enter into contracts paying the Government price for coal at the mouth of the mines. The operators of the State refused to sell for less than the Government price. The result was that no contracts were made for some time, and many of the mines of the State were idle a part of March, all of April, and some of them until well along in May. Mines in other states were working, and this caused a large number of miners from this State to leave for other mining fields. It is estimated that between 1200 and 1500 miners left the southern Iowa fields for this reason.

Beginning with the prices fixed at mine mouth by the Government in August, 1917, the price of coal has been advanced on several occasions. An advance was given to the miners and other mine workers by the Washington agreement, which became effective in this State on Nov. 1, 1917. The Government allowed this advance to be added onto the cost of coal at mine mouth, and later the fuel committee fixed the price of coal placed in bins in Des Moines at $5.65. A general freight rate advance became effective in June, 1918, but no advance in coal was made here until September following, when the fuel committee fixed the price for Des Moines, put in the consumer's cellar, at $6.15 per ton. This is almost double the price paid for the same kind and grade of coal three years ago.

In 1917, 9,049,806 tons of coal was produced, while 15,464 men were given employment in and around the mines. This increase in tonnage was made with but few more men employed than in former years, and was possible because the mines were able to keep going through most of the summer months.

Labor conditions were exceptionally good in and around the mines of the State in 1918, and but few suspensions of mine work were caused by strikes or disagreements. These were chiefly on account of differences as to the meaning and terms of the agreement between the miners and operators, as affecting some particular work done in the mine, or some action taken either by the miners or operators.

The year 1918 has seen a number of new operations in the State, and all these new mines are being well equipped for future production.

Michigan.[1]—The output of coal from the mines of Michigan during the 12 months ending Nov. 30, 1918, amounted to 1,501,053 tons. This included 154,303 tons of pick-mined coal and 1,346,750 tons of machine-mined coal. The details of operation are shown in the accompanying table.

[1] M. D. King, Chief Assistant, Department of Labor, Lansing, Mich., *Coal Age*, Jan. 16, 1919.

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SUMMARY OF MICHIGAN COAL MINING STATISTICS FOR 1918

Number of mines in operation during the year	21
Average number of men employed	2,137
Average number of hours worked per day	7.8
Average number of days worked per month	22.4
Average daily earnings of each employee	$5.45
Aggregate amount of wages paid	$3,113,028.83
Total number of kegs of powder used	16,403
Aggregate tonnage of pick-mined coal	154,303
Aggregate tonnage of machine-mined coal	1,346,750
Total number tons of coal mined	1,501,053
Aggregate cost of output	$5,022,151.96
Average cost of coal per ton	$3.35

Missouri.[1]—The year 1918 broke all records in Missouri's history in the production of coal. The total output reached approximately 6,000,000 tons, which shows a gain of 500,000 tons over 1917. This tonnage was produced in 32 counties, Macon, Lafayette, Barton, Adair and Ray counties being the chief producers.

Missouri is unfortunate, in comparison with some adjoining states, as its largest coal beds do not exceed 5 ft. in thickness, and sometimes its largest annual tonnage comes from the Lexington seam, which averages from 20 to 22 in. in thickness. The mines have worked full time and practically every mine was in operation.

The production was curtailed in some respects in many counties on account of the shortage of labor, as many of the miners joined the colors. The operators and miners have worked in harmony throughout the year, as there were no labor disputes and both sides seemed to agree that it was their patriotic duty to produce coal.

Montana.[2]—Coal production in Montana for the year ended June 30, 1918, was the largest in the history of the State, in spite of some adverse influences which were experienced in the shape of a scarcity of labor and a shortage of cars. The increase was due to industrial activity, the demand being far in excess of the supply at all times.

During the year in question many new mines, mostly wagon operations, were opened, while some old ones temporarily abandoned were reopened.

The only labor trouble of any importance occurred at the mine of the Republican Coal Co. at Klein, in Musselshell County. At this mine the men were on strike for a period of about 10 weeks. This reduced their output for the year by about 100,000 tons. With the exception of this strike, the year in question was free from labor troubles and as a general rule the relationship existing between the employer and the employee was pleasant, each striving to adhere to the conditions and obligations that all had assumed.

No great disaster, such as a mine explosion, occurred at any of the mines of the State; 21 fatal accidents occurred in the coal mines during the year from July 1, 1917, to June 30, 1918.

[1] George Hill, Chief Mine Inspector, Bevier, Mo., *Coal Age*, Jan. 16, 1919.
[2] John Sanderson, *Coal Age*, Jan. 16, 1919.

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SUMMARY OF COAL-MINE OPERATIONS OF MONTANA

Number of mines reporting to the Mines Department	88
Machine operators employed	228
Loaders	1,032
Miners	1,496
Inside daymen	1,151
Outside daymen	839
Total number of men employed in and about the mines	4,746
Total tonnage produced	4,515,414
Total number of lives lost	21
Tons produced per life lost	215,020
Number of men employed per fatal accident	226
Number killed per thousand men employed	4½
Number of kegs of powder used	101,913
Tons of coal mined by machine	1,961,743
Tons of coal mined by hand	2,553,671
Per cent. of coal mined by machine	43
Per cent. of coal mined by hand	57
Total value of mine output	$9,525,386

New Mexico.[1]—A year of unusual activity in coal mining was witnessed in New Mexico in 1918. No strikes or labor disturbances occurred during the year. The demand for coal was unlimited. The railroads gave the mines excellent service. There was but little loss of time on account of a shortage of cars. The scale of wages paid to the mine workers was the highest ever known. Yet notwithstanding these favorable conditions, the State fell behind the production for the year 1917. The decrease totaled fully a half million tons less than the mines are capable of producing.

The output for the year 1918 amounted to 4,037,726 short tons. Of this 47,050 tons was anthracite, 3,229,387 tons bituminous, and 761,289 tons semi-bituminous. The value of the coal mined amounted to $9,876,-361. In operating the mines 40,506 tons was used; 1,126,935 tons was shipped to the coke ovens, and 2,870,265 tons was sold. The coke ovens made 607,241 tons of coke, valued at $2,448,494.

The number of men and boys employed at the mines was: miners, 3070; day men underground, 837; boys underground, 45; 876 day men and 45 boys were employed on top; 315 men were employed at the coke ovens. There was 1,209,401 tons of coal cut by machines and 2,828,325 tons pick-mined.

Making an analysis and comparison of the reports of the large companies for the years 1917 and 1918, and reducing them to a like basis, we find the average loss per man per day for the year 1918 is 0.83 ton. This —including only the three largest companies—amounts to over 300,000 tons. The companies were short of men and were thus compelled to hire everybody who came looking for work. The high scale of wages paid at the mines, together with the fact that coal miners were placed in a deferred class by the draft board, caused many men to seek work in the coal mines.

Many of these men not only had no experience in the mines, but were

[1] W. W. Risdon, State Mine Inspector, Albuquerque, N. M., *Coal Age*, Jan. 16, 1919.

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indolent as well. There were enough of these shiftless and inexperienced men, together with a few Austrians, who worked only enough to make expenses, to cut down the production and cause the loss mentioned. Daily records kept of the men who reported for work in the mines show that for nine months there were from 25 to 35 per cent. of the men laying off every day.

In addition to large re-investments of earnings into permanent equipment, thus making for efficiency, the large companies are devoting much time, attention and money to bettering the social and living conditions of their employees. During the year several hundred thousands of dollars have been spent in the mining towns in renovating, repairing and repainting the dwellings; in removing old shacks and replacing them with comfortable houses; inclosing the yard of each dwelling with a fence; in building coal-houses and providing garbage cans and making a general clean up of the camps. The living conditions of the average mine worker in these towns is equal—if not superior—to the living conditions of the workingman in the large towns of the State, and far ahead of anything New Mexico has to offer in its country districts.

North Dakota.[1]—The estimated coal production of North Dakota for the calendar year 1918 is about 1,000,000 tons. This estimate is based on the assumption that the same increase over that of the previous year will be shown in 1918 as was attained in 1917. The forecast for the coming year is difficult and uncertain. It is considered doubtful if the production for 1919 will exceed that of 1918 to any great extent. This belief arises from the scarcity of labor and the high wages demanded by what miners are available.

South Dakota.[2]—As a coal-mining state South Dakota has as yet gained but little prominence, and for the year 1918 the production was only 10,100 short tons. The entire output was used in the immediate vicinity of the mines as a domestic fuel, no railroad shipments being recorded. The output shows a decrease over the previous year, the decline being due to a shortage of labor. With wages ranging from $4 to $6 per day, the operators experienced difficulty in obtaining satisfactory help and in some instances were forced to suspend work. With the return to normal times this barrier to the development of this natural resource will be removed and steady increases may be anticipated.

The mines, with the exception of those in Dewey County, are situated so far from railroad transportation as to make shipments to other localities impractical. This condition limits the output to an amount that can be used locally.

[1] W. H. Robinson, State Engineer, Bismarck, N. D., *Coal Age*, Jan. 16, 1919.
[2] Otto Ellerman, State Mine Inspector, Lead, S. D., *Coal Age*, Jan. 16, 1919.

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At the November election in this State, Amendment F to the State Constitution carried by a large majority. This authorizes the State to engage in the coal-mining business and for that purpose to acquire by purchase or appropriation all necessary lands, structures, easements, tracks, rights-of-way, equipment, cars, motive power, implements and materials. The amendment further provides that the State may pledge its credit to secure funds for this purpose. No expenditure of money, however, shall be made except upon a vote of two-thirds of the members of each branch of the Legislature.

To investigate the coal possibilities within the State, a commission was appointed and its report will be made to the Legislature, meeting during the early part of 1919. The action of the Legislature in voting funds for the development and commercializing of the coal deposits will depend largely on the report of the commission.

Ohio.[1]—The coal industry in Ohio during 1918 reached a magnitude never before attained. Ohio produced 41,677,986 tons of coal during the year 1917; for the year 1918 the tonnage was about 50,000,000. Lake shipments alone amounted to 29,388,242 tons from April until navigation closed Dec. 4.

The demand for fuel was unusual, and every effort was put forth to meet it. Of material aid in this respect was the fact that there was no such shortage of cars as was experienced during 1917. In the early part of 1918 such a shortage made itself felt pretty generally over the State. This was most acute in the Hocking Valley, and was the cause of the mines of that district averaging only about 3 days a week for the first 3 months. However, the evolving of the "zone system" greatly facilitated the supplying of cars, and during the summer and fall most of the districts had a car supply of from 80 to 100 per cent., while practically all districts reached a supply of 100 per cent. during the last two months, when the signing of the armistice closed many of the mines.

While many old mines that had been abandoned for years were reopened, and hundreds of small mines were opened up during this period of unusual activity in the coal business, it is estimated that there were no more men employed in 1918 than in 1917, if as many. In 1917 the mines averaged 51,286 employees. In spite of this the deputy mine inspectors of this State reported over 1600 mines operating during the last year.

There were no labor troubles. The fixing of prices by the United States Fuel Administration left less cause for disagreement, and the customary petty disputes were noticeably absent.

The stripping operations of this State are coming to take an important

[1] Jerome Watson, Chief Deputy and Safety Commissioner of Mines, Columbus, Ohio, *Coal Age*, Jan. 16, 1919.

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place in the coal production. Figures for 1918 will show a marked increase over 1917, when more than 1¼ million tons was produced in this manner.

Ohio mines were singularly fortunate in having experienced no serious explosions or mine fires through the pressure of producing a high tonnage. While any accident causing a single death or injury is regrettable, the total number of such accidents reported for the year 1918 was in no way exceptional in proportion to the output, the total number of fatalities being 147.

Oklahoma.[1]—This country's participation in the great conflict in Europe enabled the mines of Oklahoma during the year ending June 30, 1918, to work almost continuously. Assured of prosperity, operators made many substantial improvements on their properties. The miners also showed great loyalty toward the Government by overlooking many petty differences, and as a result the numerous shut-downs caused by local troubles, which prevailed before the war, were almost entirely done away with. The production of coal was thus greatly increased.

But a peculiar condition exists in Oklahoma, one that does not exist in the old coal-mining states and one that has retarded the mining industry to a great extent. The coal area being largely on Indian lands was segregated by the Government and has been leased to the operators of the State through the Secretary of the Interior on a royalty basis. Several years ago the Secretary of the Interior decided that it was unwise to make any more leases, and as a result there are thousands of acres of coal in the State of Oklahoma as yet undeveloped. Congress, however, eventually provided for the sale of coal and asphalt Indian lands, and many tracts have been sold recently, while the rest is subject to sale at any time. This is going to bring about the rapid development of the coal fields of Oklahoma, and will be the means of this State forging to the front and coming to be one of the foremost among the states of the Union in the production of fuel. There is a vast area underlaid with a good grade of bituminous coal.

The mines of this State, generally speaking, generate large quantities of gas and a dust of a highly combustible nature. This requires strict legal regulation and supervision by the Mining Department in order to safeguard the lives of the miners.

The tonnages produced in the years ending June 30, 1917 and 1918, and the different grades of coal made are as follows:

	1917.	1918.
Lump	548,777	633,688
Nut	131,716	180,035
Pea and slack	474,139	468,841
Run of mine	2,727,065	3,206,500
Total	3,861,697	4,489,064

[1] Edward Boyle, State Coal Mine Inspector, McAlester, Okla., *Coal Age.*, Jan. 16, 1919.

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Pennsylvania.[1]—According to most careful estimates, the production of coal in Pennsylvania in 1918 reached about 272,373,714 net tons, of which 99,514,334 tons was anthracite and 172,859,380 tons bituminous. The coke production probably amounted to 24,000,000 net tons. The number of employees in the anthracite region was 147,868 and in the bituminous region 172,600.

The number of fatalities during the year was 1009, of which 541 occurred in the anthracite mines and 468 in the bituminous mines. In 1917 the production was 271,519,710 tons and the number of fatal accidents 1075. The record of the past year both as to production and accidents is one to be proud of, and this is particularly true regarding the fatalities. The usual dangers that meet the mine workers from day to day were increased by the number of unskilled men employed and by the frantic haste to produce coal, with the consequent carelessness on the part of the miners.

The Federal regulation of mining operations and of practically all the other branches of the coal industry has not, although a most radical innovation, proved an unmixed evil. Indeed the violent protests at first heard when the Government made known its intention to control and supervise the trade to a certain extent were superseded in some quarters by expressions of positive approval. Perhaps the experience of the past two or three years may demonstrate the wisdom of closer relations between the Government and the business interests.

In addition to the shortage of labor the uncertainty of car supply was a potent factor in keeping down production. The epidemic of influenza also interfered greatly with output. But these difficulties will be helpful in causing greater activity at the mines in the future.

Pennsylvania, Anthracite.[1]—In spite of adverse conditions such as in no previous time in its history have beset the anthracite industry, the production of hard coal in 1918 was maintained to over 99 per cent. of the maximum yield of the region, that of 1917. The final reports on shipments of anthracite in 1918 compiled by the Geological Survey show an output of 76,721,157 gross tons, a decrease compared with 77,490,043 gross tons in 1917 of 1 per cent. Freshly mined coal, the breaker product, decreased nearly 2,000,000 tons, or 2.8 per cent., washery product increased 1,140,970 tons, or 21.3 per cent., and dredge product increased 77,244 tons, or 164 per cent. The decrease in output of mines and increase in culm-bank and river coal were general in all three regions.

The first of the adverse conditions that affected the industry in 1918 was the continuous cold weather that, beginning early in December,

[1] Frank Hall, Deputy Chief, Department of Mines, Harrisburg, Pa., *Coal Age*, Jan. 16, 1919.
[2] E. W. Parker, *Coal Age*, Jan. 16, 1919, with figures revised later.

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PRODUCTION OF BITUMINOUS COAL AND COKE IN PENNSYLVANIA IN 1918, FATAL ACCIDENTS AND COAL CONSUMED AT MINES

District.	Production, Net Tons.	Employees.	Coke Production, Net Tons.	Fatal Accidents.	Coal Consumed at Mines, Net Tons.
1	5,876,816	6,500	586,336	16	72,000
2	6,155,882	5,776	1,914,580	14	145,266
3	3,920,000	5,390	.....	11	145,000
4	4,360,139	5,121	131,715	12	151,426
5	6,850,000	6,750	3,285,000	20	150,000
6	5,252,559	4,572	1,115,352	14	87,310
7	5,350,000	4,890	.....	21	100,240
8	4,899,000	6,120	.....	6	54,000
9	6,650,000	6,710	2,663,500	12	180,000
10	4,073,456	4,934	10,000	8	93,000
11	7,682,015	6,710	2,676,819	11	185,445
12	5,500,000	5,100	455,299	20	200,000
13	3,750,000	3,250	.....	8	40,000
14	4,500,000	4,300	.....	16	100,000
15	5,512,500	6,889	26,000	10	86,000
16	9,200,000	8,300	4,600,000	34	200,000
17	5,338,948	5,666	.....	15	9,611
18	5,250,000	7,525	150,000	18	220,000
19	6,750,000	5,460	26,500	20	200,000
20	4,830,000	5,425	.....	16	100,000
21	7,030,683	6,590	198,750	23	278,440
22	4,472,421	3,540	92,705	9	133,342
23	7,400,000	6,900	2,500,000	18	170,000
24	5,908,464	5,960	.....	13	80,406
25	5,517,500	5,396	.....	15	90,500
26	5,473,300	4,880	.....	25	65,680
27	5,850,000	5,000	2,245,000	13	72,000
28	5,694,697	5,500	22,000	9	240,000
29	6,911,000	5,796	.....	23	120,000
30	6,900,000	7,650	395,000	18	140,000
Total	172,859,380	172,600	23,094,556	468	3,909,666

extended practically without interruption through January, February and March, seriously interfering with the operation of the breakers and with surface transportation. Notwithstanding the abnormal weather conditions, however, production during these 3 months was well maintained, February shipments making the second best record for that month in the history of anthracite mining, while March made the record for any month, with shipments amounting to a little over 7,275,000 tons.

Frozen switches, car wheels and water pipes, snow drifts and other troubles incident to the worst winter in the records of the weather bureau were overcome, for following the wage bonus granted by the supplementary agreement of November, 1917, the mine workers had determined to make 1918 the record year of anthracite production, and thus further increase their earnings. This determination was encouraged by mine operators, who in addition to spreading "win-the-war" propaganda among the mine workers, expended millions of dollars in mechanical equipment and labor-saving devices in order to increase production.

The record made in the first 3 months of the year, showing an increase of more than 600,000 tons over the same period of 1917, would have been maintained and the production for the year would have shown a gain over the preceding year of from 2,000,000 to 2,500,000 tons, had the

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PRODUCTION OF ANTHRACITE COAL IN PENNSYLVANIA IN 1918, FATAL ACCIDENTS AND COAL CONSUMED AT MINES

District.	Production, Gross Tons.	Employees.	Fatal Accidents.	Coal Consumed at Mines, Net Tons.
1	3,307,766	5,963	16	263,150
2	3,149,169	6,171	15	305,476
3	3,371,694	5,616	18	373,110
4	2,281,578	5,173	20	235,202
5	3,586,370	6,222	30	198,098
6	3,655,069	5,945	19	288,708
7	2,783,122	5,629	17	157,941
8	4,763,319	8,280	24	472,000
9	3,026,478	5,308	29	337,996
10	2,951,304	5,614	27	258,583
11	3,987,060	6,027	14	351,100
12	3,736,225	7,615	20	300,000
13	4,233,082	6,741	34	383,404
14	4,297,738	7,032	37	342,431
15	4,649,249	6,125	22	484,878
16	3,178,866	4,383	22	310,144
17	4,690,427	5,928	24	361,840
18	4,002,996	5,681	16	415,350
19	2,603,500	4,798	16	418,500
20	3,415,531	5,770	16	459,339
21	4,351,914	6,744	24	475,000
22	4,668,606	6,582	24	646,823
23	2,825,052	5,297	25	407,769
24	2,885,969	4,924	15	314,749
25	2,450,000	4,300	17	500,000
Totals.....	88,852,084	147,868	541	9,061,591

labor situation remained normal. But army and navy enlistments and drafts, and the lure of high wages and easy terms of employment in shipyards and munition plants, particularly those working on the iniquitous "cost-plus" plan, wrought havoc to the labor supply of the anthracite mines, it being estimated that not less than 33,000 men left the mining regions during the spring and summer months. Those that remained, however, true to their determination to make coal win the war, continued to maintain the production equal to, and in fact, slightly in excess, of the previous year, until October, when the spread of influenza so reduced the effective labor supply that production fell off sharply, the shipments in that month being 835,000 tons less than in the corresponding month of 1917. November shipments showed a further decrease of 1,268,654 tons as compared with November, 1917, so that not only was the gain made in the first months of the year wiped out, but a decrease set up in its stead. By December the effects of the influenza had about disappeared, and production was at approximately the same rate as in December, 1917. The shortage of labor and the epidemic were responsible for a loss in possible production to such an extent that an anticipated increase of approximately 2,500,000 tons, based on the record for the first 3 months of the year, was changed to a decrease of about 135,000 tons.

The production efficiency per man employed in 1918 was worthy of

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particular notice. The number of men employed decreased from 154,174 in 1917 to 147,121 in 1918, a loss of nearly 5 per cent. There was a gain, however, in average number of days worked from 285 to 293, 8 days or about 3 per cent. The number of men engaged in the production of anthracite was lower in 1918 than in any year since 1901; the days worked the highest in the history of the industry.

The year 1918 was unique in the annals of anthracite, as in bituminous coal mining, in that it was a full year of practically complete Governmental regulation of distribution and prices. In many respects this control was beneficial, and was particularly so as compared with the preceding 12 months. At the beginning of Governmental regulation in the summer of 1917, the public was led to believe that prices would probably be reduced, as a result of which many postponed laying in their winter's supply. Prices, however, were not reduced, but on the other hand, as a result of the wage advance in November, were increased 35 cts. a ton. The mistake of not purchasing in time was dearly paid for, as, due to the necessities created by the entrance of the United States into the world war, the demand for all kinds of fuel became acute; and in addition to this an unusually severe winter set in at an unusually early date, resulting in extraordinary demands for coal which the mines were unable to supply or the railroads to transport. Famine and panic conditions existed throughout the entire winter of 1917–18 and much inconvenience and some suffering resulted.

It is hardly necessary to discuss at length the "heatless Mondays" and other radical measures adopted for the purpose of conserving fuel. It is worth mentioning, however, that probably the most salutary effect of the action of the Fuel Administration in this regard was bringing to the mind of the people a realization of the fact that the United States was actually at war, a fact that many did not at that time fully appreciate.

During the last 2 months of 1918, prices for anthracite were higher than at any time since the Civil War. The advance in price, however, has not inured to the benefit of the operators, but has been absorbed entirely by the increase in wages given as a war bonus with the approval of the Fuel Administrator in November and made retroactive to Nov. 1. In fact, the returns on the capital invested in the anthracite industry have probably been less in 1918 than under normal conditions. It cannot be said that the Fuel Administration has been partial to the anthracite operators. Prices were strictly held to the added cost of production in labor alone, without allowance for the increased cost of supplies, and other added expenses due to war conditions.

In November, 1917, when the second war bonus was granted, it was estimated that the average increased cost per ton would be 45 cts. and the

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Fuel Administration was requested to allow that much to be added to the price. It permitted an advance of 35 cts. and although it was shown that the total average cost had been increased 78 cts., instead of 45 cts., following the November, 1917, wage increase, no allowance was made for it in adjusting the price following the new wage bonus in November, 1918, other than to permit the steam sizes to take the same advance as the domestic sizes. This was a questionable benefit, since at that time the steam sizes had become an oversupply and were being stocked in the storage yards of some of the larger companies. The industry absorbed the difference, and in addition assumed practically the entire cost of its own regulation by the Fuel Administration.

Texas.[1]—The production of coal in Texas during the year 1918 differed little from the records of previous years, being about 1,500,000 tons of bituminous and 1,300,000 tons of lignite coal. The number of bituminous mines in operation was 18, and of lignite 38. One new bituminous mine was opened and two were abandoned; ten new lignite mines were opened and five abandoned.

Progress of development of the bituminous fields is very slow, and the present outlook is that few new mines will be developed in the near future. One of the largest producing companies operating in the northern part of the State has developed a large oil field adjacent to its coal lands. Naturally the production of oil is more lucrative than that of coal, and this condition does not tend to boost the coal industry in this section. The lignite industry is progressing rapidly and the outlook is that many new mines will be developed during the coming year.

The fuel shortage which has made it impossible to secure bituminous and anthracite coal in some parts of the State has led to the use of lignite as a domestic fuel, and the results have been satisfactory, as people have found that the lignite is a good fuel for domestic use.

Texas was practically free from strikes during 1918. There was, however, considerable labor shortage in both the bituminous and lignite fields. Some mines have suffered from car shortage.

The mines of the State have continued their good record for a small number of fatal or serious accidents. Better methods of mining are being adopted at some of the mines, but at many there is room for improvement.

Utah.[2]—Unlike 1917, the year 1918 has had few unusual or exciting incidents which influenced the coal industry in Utah. With the beginning of 1918, the excitement attending the entrance of this country into the war had given place to a grim and steadfast purpose to do everything possible to help win the conflict, and the miners had settled down to work in earnest.

[1] Bruce Gentry, State Inspector of Mines, Rockdale, Texas, *Coal Age*, Jan. 16, 1919.
[2] A. C. Watts, Salt Lake City, Utah, *Coal Age*, Jan. 16, 1919.

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Now that the war has ceased and the tremendous demands of war industries for fuel have been curtailed and even stopped, there seems no reason why there should not be an ample supply of coal for all normal demands in the intermountain region. Up to January, 1918, there had not been a time for 16 consecutive months when the established operators were caught up with their orders. The situation at the end of the year was much different, and the operators were looking for new business.

Fortunately there were no disasters in the mines of the State during the past year. In one important mine the coal in an old part of the workings took fire by spontaneous combustion, and although strenuous efforts were made to load it out, it finally became necessary to seal off that portion of the mine. The area affected was near a district in which in times past the coal had been burned out, and there was considerable residual heat remaining in the strata.

The method of allotting railroad cars during 1918 was the same as followed during the previous year. The car supply throughout the year was exceptionally good—much better than in 1917.

For the fiscal year ending Nov. 30, the production of coal for the State was 5,175,813 tons, as against 4,036,069 tons for the fiscal year ending Nov. 30, 1917, or an increase of 28 per cent. Apparently the increase was due to approximately a 20-per cent. growth in production of the older mines and 8 per cent. due to new mines and small operations. No new properties of any consequence were opened during the year.

The curves of average production per miner and per man employed in and around the mines shows a decrease from last year. This is undoubtedly due to the large labor turnover for both years, but it may also arise from the increased wages the men earned.

Virginia.[1]—The estimated production of coal in the State of Virginia for the calendar year 1918 was 10,100,000 tons. The total number of mines in operation—drift, slope and shaft—was about 313. The total number of fatal accidents occurring in the mines during the fiscal year ending Aug. 31, 1918, was 41.

Washington.[2]—During the first 10 months of the year 1918 the coal mines of the State of Washington produced 3,488,008 short tons. This, with the estimated tonnage for November and December, makes the output for the State about 4,200,000 net tons for the calendar year 1918. This is the largest output this State has yet had and is an increase of about 200,000 tons over 1917.

It is estimated that 95,000 tons of coke was produced at the mines in 1918, or about the same amount as in the previous year. This does not

[1] *Coal Age*, Jan. 16, 1919.
[2] James Bagley, State Mine Inspector, Seattle, Wash., *Coal Age*, Jan. 16, 1919.

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include the coke produced at the plant of the Seattle Lighting Co., located at Seattle, Wash. Fifty-seven mines and openings of all kinds operated during the year, with an average of about 5800 men employed, this being an increase of 500 employees over the previous year. They worked an average of 270 days.

While the production during the past year was the largest the State has had, it could have been increased if the market demanded it. A shortage of labor reduced the output at some of the mines during the summer. due to the large number of men drafted into the army and to many of the mine employees securing employment at the shipyards on Puget Sound. In the closing months of the year no labor shortage was reported.

The mines of the State are operated under agreement with the United Mine Workers of America. No serious labor trouble occurred during the year, the operators and their employees both working together for larger production.

The number of fatal accidents was large because of an explosion at the Burnett mine on Aug. 28, in which twelve persons were killed. The mine was worked with approved safety lamps and the explosion was thought to have occurred when one of the fire-bosses ignited a shot when gas was present. Thirty-three fatal accidents occurred to Dec. 21.

Many improvements tending toward the safety and comfort of the employees have been made in and around the mines during the past year. All mines that generate explosive gas, in any quantity, have been placed on approved safety lamps. Mine rescue equipment has been placed at all mines where over twenty men are employed. Wash and change-houses, for the accommodation of the employees, have been built at all mines where a majority of the men have petitioned for them. New cottages and up-to-date hotels have been built at several of the mines, and on the whole the living conditions improved over former years.

West Virginia.[1]—The only figures obtainable on coal production for 1918 in West Virginia are those covering the fiscal year ending June 30, 1918. These reveal a material increase over the preceding fiscal year, and it is probable that were figures available for the calendar year of 1918 still further increases would be shown, unless the sudden softening of the coal market following the signing of the armistice terms caused a slump in operations sufficient to offset gains made throughout the rest of the year.

The total production of coal in West Virginia during the period July 1, 1917, to July 1, 1918, was 80,674,913 gross tons, which reduced to net tons gave the State a total production of 90,355,903 tons. This was an increase over the previous fiscal year of 868,261 gross tons, or 972,447

[1] *Coal Age*, Jan. 16, 1919.

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net tons. This large tonnage was produced by 71,075 inside employees and 18,272 outside employees, but only 710 more inside employees and 2542 outside men were used in the latter year to bring about the increase given.

There were 667 companies with 1203 mines in operation during the fiscal year ending June 30, 1917. This number was increased to 793 companies with 1359 mines during the year ending June 30, 1918—an increase of 126 companies and 156 mines. Despite the fact that a less number of men were engaged in the manufacture of coke during the 1918 fiscal year than was the case during the previous year—the figures being 2518 as against 2570—yet there was an increase in the coke manufactured, the figures being 3,122,722 tons as against 2,533,314 tons, or an increase of 589,408 tons.

During the year the county of Summers began to produce coal for the first time. The county producing the largest tonnage during the fiscal year ending June 30, 1918, was McDowell, with a total production of 17,806,400 gross tons. Logan ranked next with 9,230,078 and Fayette next with 8,828,080 gross tons. The county producing the smallest amount of coal was Summers, with only 5338 tons.

It is estimated by the State Department of Mines that there were between 250 and 300 wagon mines in existence at the end of the fiscal year, many of which have ceased to operate since the signing of the armistice.

The mining industry labored under many handicaps at the beginning of the 1918 calendar year. Chief among these were inadequate transportation facilities and a totally inadequate car supply. With the advent of spring, however, the car supply improved, but floods interrupted operations. When the old system of car distribution was abolished and the mines were given an adequate car supply, production shot upward, although affected by the drafting of men for the army, reaching a peak the latter part of July. The mines also gave promise of eclipsing their previous performance in October, when the influenza epidemic spread throughout the State, seriously affecting production. About the time the industry was beginning to recover from the influenza epidemic, hostilities ceased, and following a slump in the market, production dropped materially, reaching its lowest point during Christmas week.

Wyoming, District No. 1.[1]—Coal production of District No. 1, of Wyoming, for the year ending Sept. 30, 1918, was the largest in its history. The mines worked full time, with a scarcity of men. The demand for coal has never been greater. Each mine was taxed to its utmost, with each striving to meet the demand in order to bring the war to a victorious

[1] George Blacker, State Mine Inspector, Cumberland, Wyo., *Coal Age*, Jan. 16, 1919.

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conclusion. Relations between the operators and miners were pleasant, and only one object was in view, that of winning the war.

SUMMARY OF COAL PRODUCTION IN DISTRICT NO. 1, WYOMING

Year.	Tons.	Men Employed.	Number of Fatal Accidents.	Total Coal for Each Life Lost.	Number of Employees for Each Life Lost.	Number Killed per 1,000 Employed.	Number of Shipping Mines.	Av. Days of Operation of All Mines.
1911	4,865,761	5,446	22	221,170	248	4.1		
1912	5,500,253	5,673	35	157,150	162	6.1		
1913	5,229,817	5,670	21	249,038	270	3.7		
1914	5,137,843	6,069	43	123,670	141	7.7		
1915	4,460,169	5,363	18	247,787	298	3.3		
1916	5,526,332	4,838	22	251,220	222	4.5		
1917	6,047,748	5,176	36	167,993	144	7.0	36	244
1918	6,244,731	5,165	30	208,158	172	5.7	45	277

Many new mines were opened during the year, but their development was slow because of the great scarcity of men.

Wyoming, District No. 2.[1]—During the fiscal year ending Sept. 30, 1918, the production of District No. 2, Wyoming, was greater than ever before. The total tonnage produced was 3,172,538 short tons. The average number of 8-hour days worked was approximately 250.

CHIEF MINES OF WYOMING DISTRICT NO. 2—THEIR OUTPUTS DURING FISCAL YEAR 1918

	Net Tons.
Sheridan Coal Mines, Nos. 7 and 8	326,932
Acme Coal Co.	421,492
Amalgamated Coal Corporation	116,312
Carney Coal Co.	413,953
Wyoming Coal Co.	430,099
Kooi Coal Co.	273,591
Cambria Fuel Co.	361,088
Owl Creek Coal Co.	309,384
Big Horn Collieries Co.	264,735
Poposia Coal Co.	254,950

Seven fatal accidents occurred, four arising from mine cars, two from falling coal and one attributable to explosives. One other fatality was listed, but was not charged to coal mining. This made one man killed for every 453,220 tons produced, or 2.737 men killed for each 1000 employed. There was 48,069 tons produced for each non-fatal accident. The tonnage produced was disposed of as follows: to railroads, 1,265,068 tons; to commercial users, 1,752,855 tons. The slack shipped amounted to 219,786 tons.

As a whole, the miners have been well satisfied during the past year, laying aside their personal grievances in order to back up the United States during the war overseas. The total number of men employed amounted to 2558. The working forces of the mines were distributed as follows: Miners, 1441; daymen, inside, 647; daymen, outside, 470.

The Sheridan No. 8 mine is the only new one now producing coal. It operated during 10 months of the last fiscal year. It reaches a 47 ft. 6 in. bed of clean coal that is characteristic of the coal measures of northern Wyoming.

[1] R. V. Hotchkiss, State Mine Inspector, Sheridan, Wyo., *Coal Age*, Jan. 16, 1919.

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Imports and Exports

The following is a comparative statement of imports and exports of the United States for the past 4 years, in long tons:

	1915.	1916.	1917.	1918.
Imports:				
Anthracite, total	2,998	5,693	11,188	33,279
Bituminous, total	1,521,237	1,530,212	1,293,262	1,301,229
United Kingdom	18,361	5,268	9,300	33,661
Canada	1,253,329	1,399,570	1,250,709	1,250,933
Japan	86,919	93,402	17,513	14,214
Australia	159,241	30,607	12,148	1,369
Other countries	2,887	1,365	2,592	1,052
Coke	47,520	49,067	22,207	26,936
Exports:				
Anthracite, total	3,540,406	4,165,652	5,363,666	4,435,543
Canada	3,440,009	4,068,191	.....	.....
Argentina	2,526	1,530	.....	.....
Brazil	2,415	1,154	.....	.....
Uruguay	605	.....	.....	.....
Other countries	94,851	94,804	.....	.....
Bituminous, total	16,764,857	18,977,346	21,285,320	19,956,009
Italy	2,931,581	1,735,072	560,628	9,994
Canada	8,354,350	11,839,447	16,177,571	16,191,364
Panama	515,341	427,732	618,962	504,126
Mexico	279,013	196,547	184,345	162,631
Cuba	1,165,871	1,284,172	1,410,594	1,440,457
West Indies	507,966	443,200	402,812	254,501
Argentina	786,967	921,969	317,562	178,899
Brazil	648,303	782,094	685,142	559,099
Chile	.....	.....	.....	300,062
Uruguay	158,201	152,732	60,188	228,959
Other countries	1,417,234	1,194,381	867,515	125,917
Total coal	20,305,263	23,142,998	26,648,986	24,391,552
Coke	799,562	1,048,790	1,258,321	1,506,986
Bunker coal	7,470,988	7,825,731	6,883,176	5,626,175

Coal Mine Fatalities[1]

Complete reports received from the state mine inspectors for the year 1918 show a reduction of 4.5 per cent. in the total number of fatalities in the coal mines as compared with 1917. The total number of fatalities reported to the Bureau of Mines was 2579 in 1918, as compared with 2696 in 1917. The principal decrease is in gas and coal-dust explosions. In these two items alone there is a reduction of 233 fatalities.

Complete figures for the number of men employed during 1918 are not yet available, but on account of war conditions the number undoubtedly was less than in 1917, when there were 757,317 men engaged in coal mining. The number of days worked during the year will be in excess of previous years, and the tonnage won will tend to offset shortage of labor. In 1915 the average number of days were 209; in 1916, 235; and in 1917, 251.

Concerning 76 of the 129 fatalities due to mine explosions, sufficient information was obtained to show that 51 per cent. were due to explosions

[1] Albert H. Fay, U. S. Bureau of Mines, *Coal Age*, Jan. 16, 1919; revised according to Bureau of Mines Report.

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caused by open lights and 37 per cent. were due to shots. The electric arc was responsible for about 6 per cent. This emphasizes the need of abolishing the open light in all doubtful mines, more care in the use of explosives and more thorough inspection and installation of electric lines.

In 1918 there were reported only three mine explosions and one mine fire in which more than five men were killed, representing a total of 54 fatalities as compared with seven similar disasters in 1917 resulting in 251 fatalities. This indicates a considerable advance in the use of safety devices and appliances for the prevention of mine explosions.

A chronology of these accidents and their results is as follows: May 20, Villa mine, Charleston, W. Va., mine fire, 13 killed; Aug. 7, Harmar mine, Harmarville, Penn., explosion, 5 killed; Aug. 28, Burnett mine, Burnett, Wash., explosion, 12 killed; Sept. 28, North mine, Royalton, Ill., explosion, 22 killed. Fatalities due to electricity at coal mines increased 9 during the year, or about 11 per cent. Forty-six of the 88 fatalities may be segregated and show that 28, or 61 per cent., were due to coming in direct contact with the trolley wire; 11, or 23.9 per cent., were due to contact with mining machines, while feed wires were responsible for 10 per cent. Fatalities such as these call for better installation of trolley wires, locating them out of reach of workmen, or, when this is not practicable, guards should be provided that will make it impossible for one to come in contact with the live wire. Electric haulage roads should not be used as manways where it is possible to travel along other entrances and exits. Mining machines and machine feed wires should be inspected frequently to see that the insulation is in perfect condition.

FATALITIES AT COAL MINES FOR THE YEARS 1917 AND 1918

Cause.	Number Killed.		Increase or Decrease.	Percentage of Increase or Decrease.
	1917.	1918.		
Underground:				
Falls of roof or face	1,218	1,293	+ 75	+ 5.16
Mine cars and locomotives	482	506	+ 24	+ 4.98
Gas and dust explosions	362	129	−233	−64.36
Explosives	111	135	+ 24	+21.62
Electricity	79	88	+ 9	+11.39
Miscellaneous underground	127	129	+ 2	+ 1.57
Total underground	2,379	2,280	− 99	− 4.16
Shaft:				
Total shaft	52	52	.....	.....
Surface:				
Haulage	114	118	+ 4	+ 3.51
Machinery	51	47	− 4	− 7.84
Miscellaneous	100	82	− 18	−18.00
Total surface	265	247	− 18	− 6.79
Grand total	2,696	2,579	−117	− 4.34

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Coke[1]

The Connellsville coke trade was uneventful in 1918 in the matter of market conditions, for it was under Government price control and there were no changes in basic prices. Furnace coke was limited to $6 a net ton at ovens; foundry coke, 72-hr. selected, to $7; and crushed coke to $7.30. One change was made during the year, the size of screen for crushed coke being reduced in June from 1-in. to ¾-in. In August a regulation was made limiting the price of clean screenings, over ½-in. screen, gained from old dumps, to $5.50, this material finding its market chiefly as domestic fuel. It is almost needless to say that furnace and foundry coke commanded the full Government limits throughout the year. Screenings declined fully 25 cts. under the Government limit in December. Operators were unwilling even to allow brokers any commission on furnace coke, and as Government regulations did not, contrary to the case of coal, permit brokers to charge a brokerage to consumers, there was no margin for the broker. In foundry coke the operators frequently allowed brokers a margin of 25 cts.

Operating conditions in the Connellsville coke trade were altogether unsatisfactory throughout the year, but there were wide variations. The great railroad tie-up of the winter of 1917–1918 affected scarcely any industry or region more disastrously than it did the Connellsville coke region, and yet there was scarcely any railroad freight service more important than that of moving Connellsville coke; for on it depended in great measure the pig-iron production, and consequently the steel production of the country, when steel was an essential for winning the war. Practically every ton of curtailment in Connellsville coke meant a curtailment in steel output.

During the major portion of 1916 the Connellsville region shipped an average of over 425,000 tons of coke a week. In 1917 the average dropped, chiefly on account of traffic conditions, to 336,000 tons a week, which was bad enough; but in 1918, up to the middle of February, shipments were less than 250,000 tons a week. Gradually conditions improved until by the middle of the year shipments were running at 350,000 tons a week. The car service was practically satisfactory, but labor was in short supply, and there were heavy drafts upon the coal resources of the Connellsville region in favor of by-product coke ovens. As a war measure, on account of the by-products, every effort was made to put coal through by-product ovens rather than beehive ovens.

In the late months of the year production of Connellsville coke was seriously interfered with by the epidemic of influenza. Many men were

[1] B. E. V. Luty, *Coal Age*, Jan. 16, 1919.

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attacked, while on account of the scarcity of help many men stayed at home to nurse members of their families who were affected. Inoculation was practised to a considerable extent and results from inoculation were quite favorable. So great was the curtailment in output that despite the slackening in the iron industry that occurred after the signing of the armistice Nov. 11, there was a distinct shortage of coke and a few blast furnaces were forced to bank at times, while many operated at reduced blast pressures to conserve their meager supplies of coke.

The time was, but a few years ago, that the typical Connellsville coke operator could not see but that the demand for Connellsville coke would continue until the coal was exhausted. Any suggestion that the coal would be shipped in large quantities for conversion into coke by by-product ovens was scorned. The thought of Connellsville coal going through a by-product oven was regarded almost as an insult to the coal. Eventually events proved otherwise, and in no year was there such a great diversion of Connellsville coal to the by-product coking process as in 1918. This arose from the double effect of the completion during the year of many by-product ovens directly tributary to Connellsville coal, and the necessity of operating all such ovens in full even if beehive ovens had to be closed, because the by-products were needed for war purposes. For a time the shipments of Connellsville coal averaged 250,000 tons a week, chiefly for by-product coking. This represented about 40 per cent. as much coke as the Connellsville region had itself made in its best days.

The most important single operation in by-product coking directly associated with the Connellsville region was the Clairton plant of the Carnegie Steel Co. This plant was projected several years before, and it had been expected to get it in operation in 1917; but the first coke was not made until 1918, in which year the whole 640 ovens originally projected were completed, leaving under construction 128 ovens of a second batch of 640 ovens, the construction of which will proceed slowly. In the case of the Clairton operation, as with several other by-product plants in the Pittsburgh, valley and lake-front districts, the by-product ovens have been built with the direct purpose of supplanting beehive ovens in the Connellsville region, owned by the same interests, so that the same coal will be used, and by the same interests. In some cases coal from other districts will be used to an extent. In one or two instances blast-furnace interests formerly purchasing Connellsville coke have built by-product ovens, and simply buy coal instead. In one notable instance the furnace interest, being in doubt as to the date of completion of its by-product ovens, made a contract which should automatically turn from coke to coal upon completion of the ovens.

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While the war halted much new construction work, it stimulated work on by-product ovens, the Government being much interested in the by-products, and work was pushed despite the great difficulties. As a result, no less than 2085 by-product retorts were completed in 1918, against 739 in 1917. In 10 years previous the average increase had been about 375 ovens per year, but a few more than that were built, as some ovens were abandoned.

According to a statement compiled by one of the largest interests engaged in building by-product ovens under contract, there were 6756 by-product ovens in the United States at the beginning of 1917, and the 739 built in that year brought the total at the close of the year to 7495. With the 2085 built in 1918 the number on Jan. 1, 1919, was 9580, with 1620 additional either in course of erection or definitely projected, pointing to a total in the not distant future of 11,200.

The weekly reports of the by-product industry, compiled by the U. S. Geological Survey for the purpose of stimulating by-product coke manufacture as a war measure, furnish interesting information as to both the capacity and the output of the industry and indicate the causes of loss of production. The Survey required that each operator report weekly his capacity and production, assigning causes for loss of production—coal shortage, labor trouble, repairs to plant, no market, and miscellaneous causes.

The coke reports of the Survey were instituted at the beginning of 1918, and a study of the reports through the year suggests that as the weeks passed and operators had occasion to assign causes for the difference between rated capacity and actual production they scaled down their ratings somewhat. Their reports at the beginning of the year indicated a total rating for the country—a few plants did not report at the outset—of 500,000 net tons of by-product coke a week. This agreed exactly with builders' estimates of 26,005,400 tons annual capacity for the 7495 ovens that had been completed to Jan. 1, 1918, while at the close of the year the operators' ratings totaled about 650,000 tons a week, or 33,800,000 tons annually, while the builders' estimate for the 9580 ovens then completed was 35,211,200 tons.

The reports in the early months of the year showed coal shortage as a predominating influence in restricting output, but later, when there was a fairly adequate coal supply, though frequently not of the description of coal the operator would have preferred, plant repairs, occasional labor trouble and miscellaneous causes were so uniformly sprinkled over the weeks that one is disposed to conclude that a reasonable expectation of output is about 90 per cent. of rated capacity. Taking this at 650,000 tons weekly, the actual commercial capacity of the by-product coke in-

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dustry Jan. 1, 1919, was about 30,420,000 net tons a year, with more than 6,000,000 tons in prospect through new construction, pointing to an eventual commercial capacity of 37,000,000 tons, the makers' rating of capacity being 42,800,000 tons. These comparisons would be entirely misunderstood if they were taken as suggesting any criticism of either coke-oven builders or coke-oven operators. In this industry, as in many others, "capacity" is merely a standard to be approached as closely as circumstances permit, and the comparisons made suggest how close the approach can be expected to be.

The rapid growth of the by-product coking industry exceeds the pace at which new blast furnaces, the chief consumers of coke, are built; and as by-product ovens will operate if necessary at the expense of idle-

COKE PRODUCTION IN THE UNITED STATES

	Beehive, Net Tons.	By-product, Net Tons.	Total, Net Tons.
1893	9,464,730	12,850	9,477,580
1900	19,457,621	1,075,727	20,533,348
1910	34,570,076	7,138,734	41,708,810
1915	27,508,255	14,072,895	41,581,150
1916	35,464,224	19,069,361	54,533,585
1917	33,167,548	22,439,280	55,606,828
1918	30,480,605	25,997,580	56,478,185

ness of beehive ovens, there must be some idleness of the latter. Taking the beehive capacity at 35,500,000 tons, the 1916 output shown in the table having been the record output in the history of the industry, and the prospective by-product output of 37,000,000 tons, as computed above, there is a total of 72,500,000 tons.

Production of Fuel Briquets

The production of fuel briquets in the United States in 1918 was 477,235 net tons, valued at $3,212,793, an increase, compared with 1917, of 70,379 tons, or 17 per cent., in quantity, and of $978,905, or 44 per cent., in value.[1] The production in 1918, which represented the results of the third successive year of material progress in the industry, was the highest yet recorded. It was more than double that in 1915. In the Eastern States production increased 59 per cent., in the Central States 37 per cent., but in the Pacific Coast States it decreased 36 per cent.

The number of plants in operation in 1918 was one less than in 1917. Three of the plants that were operated in 1917 were idle in 1918—those of the Denver Coal By-products Co. (formerly the American Coal Reduction & By-Products Co.), in Colorado; the Johnson Fuel Co., in North Dakota; and the American Briquet Co., in Pennsylvania. Two new companies at Trenton, N. J., began operations in 1918, the Fuel Briquet Co., and the Trent Brick Co. The Belgian Coal Briquette Co., of New

[1] U. S. Geol. Surv.

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York City, and the Anthracite Briquet Co., of Sunbury, Pa., expect to begin operations in 1919.

Of the 12 plants in operation in 1918, 6 used anthracite as a raw material, 1 Arkansas semi-anthracite, 1 semi-bituminous slack, 1 anthracite culm and bituminous slack, 1 bituminous slack and sub-bituminous coal, and 2 oil-gas residue. Coal-tar pitch and asphaltic pitch were used as binders by 6 plants, 1 used sulphite pitch, 2 used no binder, and 3 used a vegetable binder or employed special processes.

PEAT[1]

The output of crude peat in the United States in 1918 far exceeded that of any preceding year and the general increase, which was stimulated by the war, was shared by practically all branches of the industry. Though extensively used as fuel in Europe and widely known in the United States as a potential source of heat and power, peat has been unable in most parts of the country to compete with coal and many peat operators have therefore directed their attention to the utilization of peat in agriculture with gratifying results.

Peat fertilizer was first marketed in commercial quantities in 1908, and stock-food peat in 1912, and though there is still some prejudice against the use of these products the agricultural branch of the peat industry has been successful and the quantity of fertilizer and stock-food peat annually produced is increasing. Large quantities of these products were made in 1918, but the most striking development of the year was the production of more peat fuel in the New England States than has been manufactured commercially in the entire United States in all preceding years. Almost equally striking was the widespread interest manifested in our peat resources, which had heretofore been generally regarded as of doubtful value.

Large quantities of peat or sphagnum moss were produced and utilized in this country in 1918 for stable litter, packing material, and surgical dressing, and several hundred thousand acres of peat soils were used for the growth of both general and truck crops. The peat litter was produced by the owners of small bogs for their own use, but the packing material was sold to florists for $25 a ton. According to J. W. Hotson, of the American Red Cross, more than half a million peat moss pads were prepared in this country from October, 1917, to Nov. 11, 1918, by the Northwest and Atlantic divisions of that organization. Most of the moss was gathered by volunteer labor from bogs in Washington, Oregon, and Maine, and the pads were used in American military hospitals, both at home and abroad.

[1] U. S. Geol. Surv. *Press Bull.*

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According to statistics compiled by C. C. Osbon, of the United States Geological Survey, the quantity of crude peat produced in the United States in 1918 was 107,261 short tons, a quantity greater by 9,898 tons, or about 10 per cent., than the record output of 97,363 tons in 1917. Nearly all the producers of crude peat in this country refine their entire output, and it was therefore impossible to determine accurately the value of the raw material. However, the average price received for all refined products in 1918 was $9.78 a ton, and the gross market value was $1,047,243, a gain of $2.49 in average price per ton, and of $337,343, or about 48 per cent., in gross market value compared with 1917.

The total number of plants at which peat was commercially produced in 1918 was 25, an increase of 7 over the number operating in 1917. All the plants that operated in 1917 except 4 contributed to the output in 1918, besides 11 that were not operating in 1917. The plants known to be operating in 1918 were distributed as follows: New York and New Jersey, 4 each; Massachusetts, 3; Georgia, Illinois, Indiana, and California, 2 each; Maine, New Hampshire, Connecticut, Pennsylvania, North Carolina, and Florida, 1 each. Nearly all the producers reported that the demand for peat exceeded the supply, and some stated that on account of limited facilities they were unable to fill the orders of their regular customers.

The Increased Use of Peat.—The mounting prices of coal particularly during 1917 and 1918 acted as a strong stimulus to the use of peat as a fuel. As is well known peat occurs in many regions, but has heretofore been utilized (almost exclusively as a domestic fuel) chiefly in Denmark and in Ireland. Under the stress of war, however, its use in many cases has been extended to industrial purposes with fair success. Thus it is stated that dried and powdered peat has been employed successfully as a locomotive fuel on certain Scandinavian railways.

While no figures are available on the amount of peat consumed as industrial fuel the perfection of processes for such utilization in Scandinavia and in Denmark doubtless did much to lessen the terror of the economic bludgeon that Germany attempted to swing over the heads of these neutrals.

Coal in Foreign Countries

The data covering the coal-producing countries outside North America is fragmentary or entirely lacking. No figures whatever are available for some regions, while those for others are estimates only. The world war in which practically all of the important coal-producng countries were engaged disarranged the normal functions of most governments,

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with the result that tonnage figures, if they are ever available at all, will be months late.

With the possible exception of France and Japan it is believed that the production of practically all countries declined during 1918. Great Britain's output is known to have declined; those of Germany, Austria, the Balkan states and Russia are unknown, but it appears hardly possible that the output of any of these could have done other than decrease.

THE WORLD'S PRODUCTION OF COAL IN SHORT TONS

Country.	1913.	1914.	1915.	1916.	1917.
United States	569,960,219	513,525,477	531,619,487	590,098,175	651,402,374
Canada	15,012,178	13,594,984	13,269,023	14,461,678	14,046,759
Mexico					
Chile	1,362,334				
Peru	301,970	312,897	318,563	357,346	396,132
Austria-Hungary	59,647,957	(d)53,396,400	(d)52,679,712	50,801,602	
Belgium	25,178,285	18,423,897	15,627,858	16,458,816	18,587,942
Bosnia and Herzegovina	927,244				
Bulgaria					
France	45,108,544	33,360,885	19,908,892	23,670,000	31,847,000
Germany	305,714,664	270,594,952	259,139,786	(f)175,097,000	(f)184,427,000
Great Britain	321,922,130	297,698,617	283,570,560	287,110,153	278,319,149
Holland	2,064,608	2,160,543	2,534,284	2,897,000	3,370,000
Italy	772,802	861,265	1,042,748	1,439,538	1,898,334
Russia	37,188,480	36,414,560	31,158,400	28,962,724	
Servia					
Spain	4,731,647	4,897,360	5,414,475	6,055,727	6,261,124
Sweden	401,199	404,143	454,432	457,262	487,914
Turkey					
China	(a)15,432,200			(a)24,000,000	
Dutch East Indies	453,136	440,905			
Formosa					
India	18,163,856	18,430,974	19,156,404	19,324,826	20,398,468
Indo-China					
Japan	23,988,292	21,700,572	22,596,750	22,189,969	29,220,897
Orange Free State (e)	609,973	699,973	727,537		
Rhodesia	237,728	391,394	458,934	491,532	
Transvaal (b)	8,191,243	7,778,706	9,275,083	11,200,370	
New South Wales	11,663,865	11,663,865	10,582,889	1,262,420	9,288,011
New Zealand	2,115,834	2,548,664	2,208,624	2,527,991	
Queensland	1,162,497	1,180,825	1,147,186	1,016,654	1,174,290
Tasmania	61,648	68,130	66,000	62,244	71,021
Western Australia	351,687	357,515	321,066	337,709	
Victoria	668,524	691,640	588,104	463,074	
Total	(c)1,477,000,000	(c)1,335,000,000	(c)1,310,000,000	(c)1,392,000,000	(c)1,476,000,000

(a) Estimated. (b) Transvaal includes Natal and Cape of Good Hope and figures given are of coal sold only. (c) Approximate. (d) Hungarian production estimated at 10,000,000 short tons. (e) Represents coal sold only; probably 10 to 12 per cent. less than production. (f) From *Glückauf;* does not include lignite.

NOTE.—This table is based on a compilation of the U. S. Geological Survey, supplemented by some later statistics. Most of the figures given for the years 1914, 1915, 1916 and 1917 are obtained from other sources and represent the best information available at this writing.

The estimated productions of the various countries follow. It should be borne in mind, however, that many of these are but little better than a guess and time will doubtless reveal many errors and discrepancies.

Australia.—The production of Australia for the year 1917 was estimated at 12,000,000 tons. It is not believed that any marked increase occurred during 1918.

New Zealand.—The output of New Zealand for the year 1918 is estimated at 265,000 tons. Exact figures are not available.

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Belgium.[1]—The coal industry of Belgium has suffered the least of all of its industries and was able to keep up a fair degree of production throughout the German occupation. The following table shows the total production by provinces throughout the period of the war.

COAL PRODUCTION OF BELGIUM
(Metric tons)

	Mons.	Centre.	Charleroi.	Namur.	Liége.	Limbourg.	Total.
1913	4,406,550	3,458,640	8,148,020	829,900	5,998,480	.....	22,841,590
1914	3,578,840	2,701,550	5,764,410	534,180	4,135,070	.....	16,714,050
1915	3,310,200	2,573,430	3,875,690	410,660	4,007,520	.....	14,177,500
1916	3,705,540	3,212,860	5,223,970	497,150	4,223,350	.....	16,862,870
1917	3,869,680	2,785,400	4,671,240	437,870	3,155,510	11,640	14,931,340
1918	3,281,720	2,559,610	4,493,630	374,440	3,112,530	65,670	13,887,600

The coke production dropped to about 15 per cent. of its normal amount.

COKE PRODUCTION OF BELGIUM
(Metric tons)

	Hainaut.[2]	Liége.	Other Provinces.	Total.
1913	2,200,180	877,130	445,690	3,523,000
1914	1,406,460	595,210	?	2,001,670
1915	424,460	90,140	.....	514,600
1916	667,530	124,820	.....	792,350
1917	648,210	27,830	.....	676,040
1918	509,150	13,060	.....	522,210

Canada.[3]—The total production of marketable coal during 1918 (comprising sales, colliery consumption, and coal used in making coke, or used otherwise by colliery operators) was 14,979,213 short tons valued at $55,752,671, or an average of $3.72 per ton, and was with the exception of the year 1913 the largest production obtained in any one year from Canadian coal mines. The production in 1917 was 14,046,759 tons valued at $43,199,831, compared with which the 1918 production shows an increase of 932,454 tons, or 6.64 per cent., and $12,552,840, or 29.06 per cent., in value. The total output of coal including waste and unmarketable slack in 1918 was 15,405,958 tons as against 14,435,361 tons in 1917.

The 1918 production included 115,405 tons of anthracite, all from one mine in Alberta; 11,532,592 tons of bituminous coal, and 3,331,216 tons of lignite. The production in 1917 included 108,225 tons of anthracite; 11,154,251 tons of bituminous, and 2,784,283 tons of lignite coal.

The exports of coal in 1918 were 1,817,195 tons valued at $9,405,423, or an average of $5.17 per ton, as against exports in 1917 of 1,733,156

[1] *Annales des Mines de Belgique*, 20, 695 (1919).
[2] Hainaut includes Mons, Centre and Charleroi.
[3] From Prelim. Rept. Min. Prod. of Can., Dept. of Mines, 1918, except details for provinces, as noted.

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tons valued at $7,387,192, or an average of $4.26 per ton, showing an increase of 84,039 tons, or 4.85 per cent. in quantity. The total imports of coal of all classes in 1918 "entered for consumption" as recorded by the Department of Customs were 21,678,587 tons valued at $71,650,584, as against imports in 1917 of 20,857,460 tons valued at $70,562,357. The record shows an increase in the import of bituminous coal, but a falling off in the import of anthracite.

The total output of oven coke during 1918 was 1,234,347 short tons, made from 1,945,475 tons of coal, of which 1,348,232 tons was of domestic origin and 597,243 tons imported. The output thus averaged 0.634 tons of coke per ton of coal charged. The total coke used, or sold by producers, during the year was 1,227,292 tons valued at $10,841,251 (partly estimated), or an average of $8.83 per ton. In 1917 the total output was 1,231,865 tons of coke made from 1,928,923 tons of coal, an average of 0.639 tons of coke per ton of coal charged. The coke sold or used by producers was 1,245,862 tons valued at $6,662,581, or an average of $5.35 per ton.

At the close of the year 1560 ovens were in operation; 1041 were idle and 115 were building. The ovens under construction included 60 Koppers ovens at Sydney; 25 Williputte ovens at Sault Ste. Marie and 30 Lomax regenerative ovens at Anyox, B. C.

The exports of coke in 1918 were 29,612 tons, valued at $223,629, or an average of $7.55 per ton, as against exports in 1917 of 23,595 tons valued at $137,318, or an average of $5.82 per ton. The imports of coke in 1918 were 1,165,590 tons valued at $8,975,455, or an average of $7.70 per ton, as against imports in 1917 of 970,106 tons valued at $6,517,260, or an average of $6.72 per ton.

Of the total output of coke, 879,063 tons, or 71.2 per cent., was made in by-product ovens.

Alberta.[1]—The estimated production of coal in the Province of Alberta for the year 1918 was approximately 6,250,000 short tons.

ALBERTA COAL PRODUCTION FOR TEN YEARS

Year.	Output in Short Tons.
1909	2,174,329
1910	3,030,757
1911	1,694,564
1912	3,446,349
1913	4,306,346
1914	3,821,739
1915	3,434,891
1916	4,648,604
1917	4,863,414
1918 (estimated)	6,250,000

The market for Alberta coal has been extended to such an extent that 433,331 tons was shipped into the Province of Manitoba during the first

[1] J. T. Stirling, Chief Inspector of Mines, *Coal Age*, Jan. 16, 1919.

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10 months of the year 1918, as compared with 188,647 tons during the same period of 1917. This additional market was obtained largely owing to the fact that the shipments of coal from the United States to Canada were considerably decreased during 1918, and also because an extensive publicity campaign was started by the provincial government of Alberta warning consumers to put in a supply of fuel at the earliest opportunity; as a result a much larger proportion of the fuel required was stocked throughout the western provinces during the summer months.

Sixty-four new mines were opened during 1918 and 58 abandoned; the number at present in operation is 289 as compared with 283 at the end of 1917. Twenty-one fatal accidents occurred during the year as compared with 24 during the year 1917, and 119 non-fatal during 1918 as compared with 101 during 1917.

Notwithstanding the increased production which took place during the past twelve months, the operation of the mines was being limited at the end of the year to about 60 per cent. of their capacity owing to lack of market. A large number of the mines—particularly in northern Alberta—were during the last 3 months of the year in operation only on an average of about two days per week. It is estimated that if there had been sufficient market to keep the mines operating fairly steadily during the year 1918, approximately 10,000,000 tons of coal could have been produced without increasing the number of men employed.

British Columbia.[1]—During the year 1918 there was mined in the Province of British Columbia 2,881,915 short tons of coal, an increase of 195,354 short tons in comparison with 1917. Of this amount 1,866,571 tons was mined by the collieries of Vancouver Island, 195,191 tons by the collieries of the Nicola Princeton district, 819,785 tons by the collieries of the Crows Nest Pass district and 367 tons by the new mine at Telkwa in the northern district.

Of the total amount of coal mined approximately 280,746 long tons or 314,435 short tons was converted into coke. The total coke production for British Columbia was approximately 190,696 long tons. Of this amount the Crows Nest Pass Collieries made 166,003 tons. The Canadian Collieries (D), Ltd., made 39,776 tons at its ovens at Union Bay, Comox colliery.

Strikes, mine fires and the ravages of the influenza epidemic have been responsible for a considerable loss in output during the year 1918. To these causes must also be added a serious shortage of labor during the year. A strike in the Crows Nest Pass district was responsible for the loss of approximately 60,000 long tons, while the adoption of the single shift, and the ravages of the influenza epidemic, have been responsible for

[1] George Wilkinson, Chief Inspector of Mines, Victoria, B. C., *Coal Age*, Jan. 16, 1919.

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the loss of approximately 75,000 more in the same district. On Vancouver Island the East Wellington mine of the British Columbia Coal Mining Co. was closed down the first 8 months of the year on account of a fire in the workings. This resulted in a loss of output of approximately 50,000 long tons. The influenza epidemic in this district has been responsible for a further loss of 50,000 tons.

The Granby Consolidated Mining, Smelting and Power Co. has opened and equipped a large mine at Cassidy's, Vancouver Island, where it has acquired a large area. The bed being mined is the famous "Douglas seam." At Anyox the company has almost completed a battery of by-product coke ovens, where it is the intention to make coke for use of the smelter at that point. During the year the Canadian Western Fuel Co. started sinking operations on two shafts which will be known as the Wakesiah mine. Coal was reached in August at a depth of about 300 ft., the bed being the famous Wellington. The Harewood mine, which had been long closed, and was reopened by the same company last year, is producing approximately 1000 tons daily. The new No. 5 mine opened by the Canadian Collieries (D), Ltd., at South Wellington is now producing about 300 tons per day. A good substantial tipple and surface equipment has been installed and this operation is capable of handling large tonnages. In the Nicola Princeton district the Fleming Coal Co. has acquired the interests of the Inland Coal and Coke Co. and has reopened the mines, which have been closed for some time. The Coalmont colliery has also been reopened, and production started. A new mine has been opened in northern British Columbia at Telkwa and has been shipping a small amount of coal to Prince Rupert.

Saskatchewan.[1]—The record output of coal for the Province of Saskatchewan, for the year 1917, was 336,726 tons, produced by 264 miners and 131 laborers from the 51 mines in operation. The amount of coal produced in the province for the ten months ended Oct. 31, 1918, was 209,799 tons, and while figures are not available for the remaining two months, it is known that the record output of the preceding year was not reached during 1918.

The mechanical equipment underground was increased slightly in 1917, when six electrical coal-cutting machines were in operation in the province, whereas four mining machines were used here during each of the previous two years. Of the four principal mines of Saskatchewan, two have electrical equipment. The Western Dominion Collieries, Ltd., produced 113,287 tons of coal in 1917 and is equipped with four electric coal-cutting machines and two electric motors underground; at the tipple of this company there is also installed a mechanical box-car loader.

[1] E. Pierce, Mine Inspector, Roche Percee, Saskatchewan, Can., *Coal Age*, Jan. 16, 1919.

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Nova Scotia.[1]—The production of the larger coal companies in Nova Scotia during 1918 was as follows, the production for the year 1913 being shown for comparison, this being the year of maximum production and the last normal year before the war:

	1913.	1918.
Dominion Coal Co.		
Springhill Mines	381,434	367,000
Sydney District	4,739,139	3,273,000
Nova Scotia Steel Co.	813,877	500,000
Acadia Coal Co.	539,121	280,000
Intercolonial Coal Co.	189,550	175,000
Inverness Coal and Ry. Co.	293,847	200,000
Maritime Coal and Ry. Co.	155,051	180,000
Other Operators	151,466	211,000
Totals	7,263,485	5,186,000

About 78 per cent. of the total production came from Cape Breton Island, comparing with a maximum production from the island of about 82 per cent.

The difference in the tonnage of coal available for commercial sale is almost altogether to be found in the sales to the Montreal markets, which in 1913 were approximately 2,000,000 tons. In 1917 and 1918 no coal was sent to the Montreal market from Nova Scotia, American coal having been used in substitution to the entire supplanting of Nova Scotia coal. There are two reasons for this reversal, one being that the production in Nova Scotia has been so reduced that no coal would have been available for Montreal markets in any case. The second reason is that the Admiralty requisitioned the coal freighters which the coal companies, in particular the Dominion Coal Co., had on long-term charters at cheap rates of hire. Until these vessels are returned, whether production recovers or not, Nova Scotian coal is excluded from competition with American coal in the Montreal market by reason of the cost of freighting.

The per ton cost of producing coal in Nova Scotia has increased during the war until it is probably not less than $4 a ton in any case, and in some cases it is a good deal more. The main reasons for the increase are reduced production and an inefficient organization of the working forces at the collieries brought about by a surplus of auxiliary workers and a shortage of face workers. While the number of men employed on the surface and underground in handling and preparing the coal is not markedly less than it was when production was 30 per cent. larger than it now is, the number of face workers or contract employees actually digging coal has been reduced by one-half.

The cost of wages, materials, and transportation as well as taxation has, of course, greatly increased the burdens on production, but the main reason for the tremendous increase in mining costs is the shortage of productive workers.

[1] F. W. Gray, *Colliery Guardian*, Feb. 7, 1919.

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A significant feature in its bearing on future costs of mining is that between 65 per cent. and 70 per cent. of all the coal now mined in Nova Scotia comes from submarine territory. In future the percentage of submarine extraction will increase, as the great bulk of the solid coal is under the sea.

No large expenditures on capital account have been made since about 1912, and a good many of the existing collieries have either exhausted their take or have had the advance development work restricted by shortage of labor. It will be several years before the collieries in Nova Scotia are in a position to produce anything like the rate of output of 1913. Irrespective of questions of labor supply, the capacity of the collieries for output has been lessened, and it will take perhaps five years to bring them back to pre-war conditions.

China.—It is believed that the production of China during 1918 was about the same as during 1917, or approximately 20,000,000 short tons.

France.—The following table[1] shows the status of the coal industry in France during the period of the war.

Year.	Production.	Importation.	Exportation.	Consumption.
1913	40,844,000	23,719,000	1,501,000	64,834,000
1914	29,787,000	18,057,000	1,500,000(e)	46,000,000(e)
1915	19,909,000	19,983,000	1,500,000(e)	38,000,000(e)
1916	21,473,000	20,422,000	1,678,000	40,000,000(e)
1917	28,891,000	17,454,000	1,487,000	44,800,000(e)
1918	28,000,000(e)	16,821,000	3,249,000	41,572,000(e)

(e) Estimated.

The German occupation involved all the mines of the Nord district and part of those of Pas-de-Calais. The mines in the occupied territory normally produced 21 million tons. All the most valuable parts of the machinery have been taken away, and the buildings for raising coal have been destroyed. Underground communication has been interrupted by flooding the works and galleries. The falling off in the output of coal during the first year of peace, for the whole of the region, may be estimated at 13 to 15 million tons.

In the entire Pas-de-Calais region it is estimated that 120 million cubic meters of water must be pumped before mining operations are resumed. The mines having been flooded, the head-frames and surface equipment were systematically dynamited, the twisted débris in many cases filling up the demolished shafts. It will probably be 5 years before this coal district can be rehabilitated and 12 to 15 years before it gets back to normal pre-war output. The first great need is for buildings in which to house the workmen.[2]

[1] *Annales des Mines de Belgique*, **20**, 603 (1919).

[2] Frank H. Probert, U. S. Bureau of Mines.

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Central Europe (Germany, Austria-Hungary, and Russia).—The London *Iron and Coal Trades Review* published the following table of coal and coke production in Germany, from *Glückauf:*

	Coal.(a)	Coke.
1913	191,511,000	32,167,000
1914	161,535,000	27,324,000
1915	146,712,000	26,359,000
1916	158,847,000	33,023,000
1917	167,311,000	33,639 000
1918	160,508,000	33,411,000

(a) Not including lignite.

The production of Austria-Hungary before the war amounted to about 60,000,000 tons annually, and of Russia about 35,000,000 tons; no recent figures are available.

Great Britain.—A statement has recently been made by a prominent member of the Government that, owing to the continued decrease in the output of coal in Great Britain, it will be necessary either to reduce the supply of coal to industry and for domestic use or to limit exports still further. As is shown by the following table, the output of coal has been decreasing intermittently since 1910, but the most significant figures are those showing the decrease in the output per miner, which amounts to practically 10 per cent. for the period mentioned:

Year.	Total Output, Long Tons.	Persons Employed.	Output Per Person.
1910	264,417,588	1,049,407	252
1911	271,878,124	1,067,213	255
1912	260,398,578	1,089,090	239
1913	287,411,869	1,127,600	255
1914	265,643,030	1,057,505	251
1915	253,206,081	953,642	265
1916	256,375,366	998,063	257
1917	248,499,240	1,021,340	243
1918	227,714,579	1,008,867	226

It will be seen that the output per person employed reached its highest point in 1915, when the number of men employed was smallest but the patriotic impulse perhaps highest. From that year, however, the individual output shows an accelerating downward movement.[1]

The British production of coke in 1917 was 21,995,125 long tons as compared with 21,389,363 tons in 1916. In 1917 there were in Great Britain 7013 beehive ovens, 1415 Coppée ovens, 1756 Simon-Carves ovens, 2217 Otto-Hilgenstock ovens, 1357 Semet-Solvay ovens, 1361 Koppers, 486 Simplex, 439 Huessener, 177 Collins, 32 MacKay-Seymour and 293 other kinds, or 16,540 in all, against 16,320 in 1916.

Holland.—The following table gives the coal production of Holland, from the Province of Limbourg, during the war. The Government has

[1] *Comm. Rept.*, June 30, 1919.

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reserved a coal field of 26,500 hectares (65,600 acres), production from which started in 1901 in the Wilhelmina mine, which yielded 489,000 tons in 1917; the Emma mine, opened in 1908, produced 557,000 tons in 1917. Two other mines, the Hendrik and the Maurits, have been started, and the Government plans to continue the development so as to produce in all 2,000,000 tons annually by 1925, 3,500,000 tons by 1935, and 6,000,000 by 1950.

PRODUCTION OF COAL IN HOLLAND
(In metric tons)

	1913.	1914.	1915.	1916.	1917.
Private mines	1,455,000	1,381,000	1,478,000	1,686,000	1,916,000
State mines	417,000	546,000	784,000	900,000	1,092,000
Total	1,872,000	1,927,000	2,262,000	2,586,000	3,008,000

The value of the output has increased rapidly, having been worth 7.72 florins per ton of coal in 1913 and 14.38 florins per ton in 1917. Before the war 70 per cent. of the production was sold in Belgium, Germany, and France. About one-fourth of the miners are now foreigners, the proportion having increased during the war due to the taking on of Belgian refugees, and German and Austrian deserters.[1]

Italy.—The production of coal and lignite in Italy in 1918 probably amounted to about 2,000,000 tons, all but about 25,000 tons being lignite.

Japan.—The output of coal in Japan for the year 1918 probably did not greatly exceed that of the previous year, when it was reported that 26,090,087 long tons was produced. A rough estimate would place the output for Japan last year at 26,000,000 tons. The production of 1917 showed an increase over that of 1916 of 5,530,000 tons, but it is not believed that so marked an increase occurred last year.

South Africa.—The production of coal in the Union of South Africa in 1917 was 10,382,623 tons, valued at £3,255,569. The increase is due to the enlarged demand for bunker coal at Durban and Delagoa Bay, caused by diversion of ships from the Suez to the Cape route to avoid enemy submarines in the Mediterranean. Contracts made by the gold mines of the Rand have kept the price of Transvaal coal steady at the moderate figure of 4s. 9d. per ton at the pit's mouth. In Natal, however, in consequence of the shipping demand, the average price advanced from 6s. 10d. in 1914 and 1915 and 7s. 5d. in 1916, to over 10s. per ton in 1917. At the end of 1918 62 concerns were producing coal. Of these 31, or exactly one-half, were located in the Transvaal, and of the remain-

[1] Information from *Annales des Mines de Belgique*, **20**, 327 (1919), which received it from *Jaarverslag van den Hoofdingenieur der Mijnen* and other official Holland publications.

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der 25 were situated in Natal, 4 in the Orange Free State, and 2 in the Cape. Of the 31 Transvaal producers 18 were in the Middelburg area (which, of course, includes Witbank), 3 were in the Spring-Brakpan area, and the remaining 10 in other localities. These returns would seem to show that there is no great difference between the numbers of productive collieries in the Transvaal and in Natal. But it must be borne in mind that there are in the Transvaal a considerable number of concerns which are not regular and consistent producers.[1]

Spain.—The production of coal in Spain in 1918 is reported at the record figure of 7,164,463 metric tons, compared with 5,680,054 tons in 1917.

Other Countries.—Many countries, localities and regions other than those mentioned above produce more or less coal. While this production is important to the country or region where the deposits are worked, it has little influence upon world industry or commerce.

[1] *So. Afr. Min. Eng. Jour.*, Feb. 22, 1919.

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COBALT

By C. W. Drury

Occurrences.—No large deposits of cobalt ore were discovered during the year 1918. A limited amount of work was done on the cobalt ores in the Blackbird District, Idaho, by the Haynes Stellite Co. of Kokomo, Ind. The property is equipped with a 10-stamp mill and concentration tables, the concentrate being shipped to Kokomo for treatment to recover the cobalt. Associated with the cobalt is copper, nickel, and gold. The property may be reached over a 36-mile wagon road from Salmon City.

A shipment from the property in British Columbia of the New Hazelton Cobalt Mines, Ltd., was made to the Government ore-testing plant at Ottawa. The mine is situated on the west side of the Rocher de Boule Mountain, and close to the line of the Grand Trunk Pacific Railway. The cobalt occurs along with gold, molybdenum, nickel, and arsenical compounds.

The shipment of cobalt products from the mines at Cobalt continued during the year 1918. The flotation concentrates produced at Cobalt do not contain large amounts of cobalt or nickel, as these minerals do not float readily. The ore received from the shippers of the Cobalt and Gowganda districts consists of silver-cobalt ore in lump form, jig and table concentrates and residues, such as those produced by the Nipissing Mining Co. and the Mining Corporation.

Metallurgy.—No new developments were made in the metallurgy of cobalt ores during the year 1918, the metallurgical treatment having become more or less standardized.

PRODUCTION OF COBALT IN CANADA (*a*)

	1917.		1918.	
	Production, Pounds.	Shipments, Pounds.	Production, Pounds.	Shipments, Pounds.
Cobalt oxide	802,448	418,703	1,176,166	477,593
Cobalt metal (*b*)	393,773	315,327	473,463	301,845
Cobalt metal in stellite	.....	81,068	101,987	102,403
Cobalt sulphate and carbonate	52,485	52,485	.....	.....
Cobalt and nickel oxides not separated	.....	4,757	.....	.....
Cobalt sulphate	.....	.....	43,097	43,097
Cobalt hydroxide	.....	.....	5,416	5,416

(*a*) Reports of Ontario Bureau of Mines and private communications.
(*b*) Cobalt metal is produced from the oxide.

Production.—During 1918 there was considerable increase in the production of metallic cobalt. The Missouri Cobalt Co. produced cobalt

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and nickel metal and oxides, as well as lead and copper products. The following table shows the production of cobalt in Canada during 1917 and 1918. The production of the Missouri Cobalt Co. in 1918 was not large, but should become an appreciable factor in 1919.

The following figures show the tonnages of the different cobalt products treated at the Canadian smelters during 1918: silver-cobalt ore, 1327 tons; concentrates 4288 tons; and residues, 2751 tons. There was also a recovery of 5,014,469 oz. of silver.

The total production of the Cobalt silver mines from 1904 to 1917 is given below.

TOTAL PRODUCTION, COBALT SILVER MINES, 1904 TO 1917(a)
(Short tons)

Year.	Nickel.		Cobalt.		Arsenic.		Silver.		Total Value.
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Ounces.	Value.	
1904	14	$3,467	16	$19,960	72	$903	206,875	$111,887	$136,217
1905	75	10,000	118	100,000	549	2,693	2,451,356	1,360,503	1,473,196
1906	160	.....	321	80,704	1,446	15,858	5,401,766	3,667,551	3,764,113
1907	370	1,174	739	104,426	2,958	40,104	10,023,311	6,155,391	6,301,095
1908	612	.....	1,224	111,118	3,672	40,373	19,437,375	9,133,378	9,284,869
1909	766	.....	1,533	94,965	4,294	61,039	25,897,825	12,461,576	12,617,580
1910	504	.....	1,098	54,699	4,897	70,709	30,645,181	15,478,047	15,603,455
1911	392	.....	852	170,800	3,806	74,609	31,507,791	15,953,847	16,199,346
1912	429	14,220	934	314,381	4,166	80,546	30,243,859	17,408,935	17,818,082
1913	377	13,326	821	420,386	3,663	64,146	29,681,975	16,553,981	17,051,839
1914	(b) 90	28,978	(b) 351	590,406	2,030	116,624	25,162,841	12,765,461	13,501,469
1915	(c) 35	28,353	(c) 206	383,261	2,490	148,379	24,746,534	12,135,816	12,695,809
1916	(c) 79	59,380	400	805,014	2,160	200,103	19,915,090	12,643,175	13,707,672
1917	(d) 155	125,071	337	1,138,190	2,592	608,483	19,401,893	16,121,013	18,028,597
Total..	4,058	283,969	8,950	4,388,400	38,789	1,524,569	274,724,172	151,950,561	158,176,339

(a) Report, Ontario Bureau of Mines, Volume XXVIII (1919).
(b) Metallic contents of nickel and cobalt oxides respectively.
(c) Metals and metallic contents of all nickel and cobalt compounds.
(d) In 1917 there was also 53 tons of copper, valued at $28,840, recovered from silver ore and concentrates shipped to United States refineries.

Trade.—During the year 1918 the price of cobalt oxide and metal varied but little; the price of commercial black cobalt oxide was $1.50 and gray oxide $1.65 per pound. Cobalt metal was quoted at $2.25 per lb. until November, when it advanced to $2.50.

The following table gives the imports into the United States of cobalt products.

IMPORTS INTO THE UNITED STATES OF COBALT PRODUCTS, COBALT, COBALT ORE AND ZAFFER, IN POUNDS
(Fiscal years ending June 30)

From	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Belgium	.....	.....	1,245	.....	.....	.....	.....
France	1,221	1,245	1,102	.....	.....	.....	.....
Germany	3,850	3,869	41,941	1,761	.....	.....	.....
England	.....	.....	4,240	.....	.....	.....	.....
Canada	879,171	306,002	148,481	22,334	144,270	138,260	161,705
Total	884,242	311,116	197,009	24,095	144,270	138,260	161,705
Imports of cobalt oxide	22,160	28,729	109,484	190,145	238,934	236,822	220,863

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By the Metal Refining Bounty Act[1] a bounty of 6 cts. per lb. was provided on refined cobalt and nickel and the oxides of these metals produced in Ontario from Ontario ores, the bounty being calculated on the metallic contents. There was provision also for a bounty of 1.5 cts. per lb. on refined copper or copper sulphate similarly produced, and on white arsenic made from mispickel 0.5 cts. per pound. The term of the Act was originally 5 years from Apr. 20, 1907, but was subsequently extended for another 5 years from Apr. 20, 1912. It expired in 1917, and was not re-enacted, and the bounties ceased to be payable on Apr. 20, 1917. The act fixed a maximum amount payable on cobalt and cobalt oxide of $30,000 per annum, and on nickel and nickel oxide of $60,000 per annum, and provided that should the production in any one year be greater than could be paid for by the maximum bounty at the rate specified in the Act, the rate should be correspondingly reduced. In 1916 the cobalt production was in excess, consequently the rate per pound of metallic contents was reduced to 3.9131 cents.

For the broken period from Jan. 1, 1917, until the expiration of the Act on Apr. 20 of the same year, the sum of $16,439.13 was earned by the refining companies.

SUMMARY OF BOUNTIES PAID, 1907–1917

	Cobalt.	Nickel.	Total.
Deloro Smelting & Refining Co.	$48,930.93	$8,166.96	$57,097.89
Coniagas Reduction Co., Ltd.	67,174.99	27,539.01	94,714.00
Metals Chemical, Ltd.	9,577.60	6,766.04	16,343.64
Canadian Smelting & Refining Co.	1,026.92	681.84	1,708.76
Standard Smelting & Refining Co.	214.92	.....	214.92
Dominion Refineries, Ltd.	62.59	.....	62.59
	$126,987.95	$43,153.85	$170,141.80

Technology.—There has been considerable experimental work done on the testing of stellite and cobalt-steel products. Cobalt is finding extensive use in the preparation of stellite and also in high-speed tool steels. The superiority and value of cobalt steel for certain classes of work has been demonstrated for several years and the consumption of stellite and cobalt steels is rapidly on the increase. Cobalt is being used extensively in high-speed tool steels which possess some remarkable properties. Besides its value in high-speed cutting tools it is also of considerable use in the preparation of cutting tools, viz., milling cutters, taps, etc. It is claimed that steel containing cobalt can be heat-treated at several hundred degrees lower than the tungsten high-speed steels.

Messrs. Guillet and Godfroid undertook a series of tests to compare the value of stellite with high-speed tool steel. They found commercial

[1]R. S. O., 1914, Chapter 23.

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samples of stellite to differ widely in composition, as may be seen from the following analyses of samples received in 1914 and one in 1917:

	1917.	1914.
Carbon	1.48	1.79
Silicon	0.17	0.78
Manganese	*Nil.*	0.72
Sulphur	0.01	.....
Phosphorus	Traces.	.....
Cobalt	55.6	34.60
Chromium	33.6	36.36
Tungsten	9.15	12.70
Molybdenum	*Nil.*	9.44
Vanadium	*Nil.*	1.00
Iron	*Nil.*	10.06

As a high-speed tool steel the alloy is an interesting one, as it can be used without any special treatment, and gives better results than many high-speed tool steels on the market. It is, however, exceedingly heterogeneous, and therefore does not by any means yield constant results. An investigation as to the influence of each of the specific constituents of the alloy on the alloy as a whole is in progress.

It was found that the hardness of stellite falls at fairly gradual rate as the temperature is raised from 0° C. to 800° C. from a value of 512 to 332 on the Brinell scale, but that on cooling again to 0° C. the original hardness is regained. Tests were also made to modify the structure of stellite by heat treatment, but very little difference was noted even after heating to 1150° C. and quenching in oil or water.

Messrs. Schoeller and Powell have published the results of extensive experiments on the determination of cobalt and nickel in cobalt steel. In the determination cobalt is precipitated as cobalt ammonium phosphate and titrated. Jones also describes a colorimetric method for the determination of cobalt.

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COPPER

By Walter Harvey Weed

During the year 1918, the copper industry of the world was for 8 months dominated by the United States Government, whose urgent demand for the metal led to the operation of the mines and smelters of this country under great pressure and maximum production.

With the signing of the armistice on Nov. 11, 1918, the world war ended and the demand for copper suddenly ceased. The war-time price continued, but the demand for peace-time industry had not revived by the end of the year, as would-be purchasers were expecting to get the metal at pre-war prices.

The world's copper production for the year 1918 was 1,395,160 metric tons,[1] compared with 1,435,721 tons[2] in 1917.

According to the U. S. Geological Survey statistician the smelter production of copper in this country was 1,908,533,595 bl. or about 1.2 per cent. more in 1918 than in 1917. The returns from Bolivia, Spain, Portugal, Russia, Germany and the war-torn countries are estimated.[3]

The world war with its imperious demand for the red metal caused a remarkable expansion of the copper industry. For the entire world there was a 33⅓-per cent. increase in 1916 over the previous year's output; and the output has been maintained at practically that figure despite greatly increased costs. The world's production for the past three years has been 4,237,234 tons, or 1,412,411 metric tons annually, though the 1918 output is given as 1,395,160 metric tons. Contrast this with 1811, when the world's production was not quite 10,000 tons, while 50 years later in 1861 the output was a trifle over 50,000 tons. With the birth of the electrical industry, increasing consumption brought the year's output to 269,096 tons in 1890; 486,600 tons in 1900, and 661,109 tons in 1910.

The copper industry was less prosperous in 1918 than in the year 1917, though insistent demand kept mine, smelting and refining plants working at high pressure, until abruptly terminated by the signing of the armistice on Nov. 11, and the stoppage of practically all buying of the metal.

[1] *Eng. Min. Jour.* figure.
[2] 1,390,991 tons according to the *American Metal Market Rept.*
[3] *Eng. Min. Jour.*, Jan. 11, 1919.

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After unprecedented prosperity in 1917, the copper mines of this country were confronted with several new and embarrassing factors. The most serious was perhaps an autocratic and unsympathetic War Industries Board, whose imperious decisions were often made without even the courtesy of a consultation.

This board fixed the governmental price at 23½ cts. per lb. until July 2, when the price was raised to 26 cts. a pound. The first price was manifestly unfair and discriminatory, since it was but 56⅔ per cent. advance over the average price for 20 years previous, whereas the price of wheat was over 250 per cent. and steel 111 per cent. over pre-war prices, the extreme advance being 233 per cent. Before the war a pound of copper would buy 9.6 lb. of steel, but in 1918 only 7.6 lb.

This unfair situation was aggravated by the tardiness of the U. S. War Department in making payment for the metal, by the insatiable demands of labor for increased wages, coupled with an increased and increasing inefficiency, and unwillingness to work full time, and last but not least by increased railroad rates.

The increase of the price to 26 cts. was offset by the increased freight rates on July 1 and increased refining costs, and the granting of a further increase of wages because of an increase in the price of the metal actually left the companies worse off than they were before the raise. With the signing of the armistice, copper sales practically ceased. The price remained fixed at 26 cts. until Jan. 1, 1919, and as producers would not sell for less, the buyers held off, knowing the metal would soon sell for less. The producers could not sell abroad, as foreign governments put obstacles in the way of transportation, and the British Government offered the accumulation of electrolytic at £105, equivalent to 18½ or 19 cts. in New York.

The copper industry was controlled through 1918 by the War Industries Board, which allotted the metal to our own and the various Allied governments as called for. This Board, in October, modified its ruling regarding importation permitting concentrates of 50 per cent. copper or better to be imported from non-enemy countries, but with no restriction on copper matte, or blister copper. On Nov. 15, after the armistice was signed, this board ruled that all mines, smelters and refineries should keep up the then existing rate of production, of wage scale and metal prices. It is interesting to note this board's statement that as civilian demands in both American and foreign industries had been very greatly curtailed and held in check for some years, a big demand would immediatey arise. It is evident that the board seriously misjudged the American and world market, and deliberately forced American producers to pile up an immense surplus, over a billion pounds, at high cost.

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It is worth noting that 445,000,000 lb. of copper (bronze) 1-ct. pieces were coined in 1918, compared with 100,000,000 in 1916.

The great American production is noteworthy because the war draft took away from the industry the younger and more energetic miners, with the result that at Butte, Mont., instead of 1¾ tons of ore mined per man per day, the output dropped to 1 ton. This decreased efficiency, together with very greatly increased labor costs, railroad freights, increased refining charges, and more than doubled supply costs, makes this great output remarkable, since it was patriotism rather than profit that kept the mines operating. From a purely business standpoint, it would have been better to shut many of the mines down, rather than stop development work and deplete ore reserves for a relatively meagre return.

Copper production does not normally respond quickly to altered prices. Pig-iron furnaces can shut down quickly and hold their stock-pile until business improves. Copper mines and smelters employing a skilled force of selected men cannot do this, because it would disband the force and mean a large and expensive period of rehabilitation and building up a new operating force.

The smaller companies made little if any profit and the development of new mines and of prospects was so costly as a result of war prices as to become less than for many years previous.

With the signing of the armistice, the big companies kept their promise to maintain production and labor prices, as is shown by the output of 161,801,916 lb. output of December, compared with 159,217,588 lb. in November and 168,638,775 lb. in October. The mine output during 1918 was remarkably uniform, varying from a maximum of 185,525,168 lb. in March to 157,992,487 in September, with a normal of 160 to 165 million pounds.

The 1918 smelter production of copper in the United States from domestic ores, together with imported ores and scrap, totaled 2,255,063,895 lb., compared with 2,277,859,962 lb. in 1917, and 2,298,101,140 lb. in 1916.

The refinery production for the year 1918 was somewhat larger than the smelter output, amounting to 2,432,385,290 lb. of refined copper (electrolytic, Lake, casting, and pig) from primary sources, which is a slight increase over the output of 2,428,546,171 lb. in 1917. Only 34,088,084 lb. was sent from the smelters to foreign refineries. The balance of 2,220,975,811 lb., together with 268,756,428 lb. of imported crude copper, was treated by eleven American refineries, whose combined annual capacity of 2,788,000,000 lb. was severely taxed during the year 1918.

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SMELTERS' PRODUCTION SINCE 1914—DELIVERIES TO REFINERIES (a)
(In Pounds)

Source.	1914.	1915.	1916.	1917.	1918.
North American ore....	1,327,488,479	1,612,450,828	2,187,328,864	2,161,627,729	2,179,825,960
Foreign ore.....	50,101,308	44,749,105	73,391,517	74,410,422	37,334,001
Scrap.....	20,894,559	29,827,203	37,380,759	41,821,811	37,903,934
Totals.....	1,398,484,346	1,687,027,136	2,298,101,140	2,277,859,962	2,255,063,895
To foreign refiners.....	37,765,920	39,734,120	38,423,577	33,261,435	34,088,084
To American refiners....	1,361,718,426	1,647,293,016	2,259,677,563	2,244,598,527	2,220,975,811
Crude copper imported..	131,125,076	140,415,314	152,770,536	274,813,001	268,746,428
Total crude copper.	1,492,843,502	1,787,708,357	2,412,448,099	2,519,411,528	2,489,722,239

(a) *Eng. Min. Jour.*

The copper production of the various states of the United States for the past six years is given in the following table.

SMELTERS' PRODUCTION OF COPPER IN THE UNITED STATES[1]
(In Pounds)

State.	1913.	1914.	1915.	1916.	1917.	1918.
Alaska.....	24,452,000	24,288,000	72,621,844	115,933,315	92,094,023	59,326,000
Arizona.....	399,849,745	387,978,852	444,089,147	692,630,286	704,156,391	765,744,496
California.....	32,390,272	29,515,488	37,935,893	51,358,334	46,824,320	57,576,860
Colorado.....	7,670,090	10,104,579	8,126,000	9,802,183	11,894,900	4,596,200
Idaho.....	8,434,028	4,856,460	5,602,000	6,741,001	6,401,988	5,068,500
Michigan.....	159,437,362	157,089,796	241,123,404	270,058,401	274,936,224	216,759,810
Montana.....	285,336,153	243,139,737	268,027,557	351,995,058	277,362,386	324,970,446
Nevada.....	84,683,961	60,078,095	66,394,906	100,143,431	115,436,671	86,361,023
New Mexico.....	46,953,414	64,338,892	75,515,138	83,013,805	110,020,997	91,462,362
Utah.....	147,591,955	153,555,902	180,951,174	225,396,808	244,443,071	230,019,737
Washington.....	(a)	(a)	(a)	(a)	2,152,560	2,189,030
Wyoming.....	448,805	165,023	1,020,926	(a)	(a)	(a)
Southern States...	24,333,014	19,213,965	18,858,677	20,018,361	18,704,304	16,630,377
Other States.....	4,155,135	4,257,068	3,431,494	15,685,226	18,127,368	9,264,845
Total.....	1,225,735,834	1,158,581,876	1,423,698,160	1,942,776,309	1,922,555,903	1,869,949,686

(a) Included in "Other States."

Although smelter production does not correspond exactly with mine production, since the ore is not smelted immediately, yet the amount in transit, and that carried in stock-piles, does not vary greatly in normal years. In 1918, however, a number of smelters received ore under contract far in excess of the smelter capacity, the accumulated excess being carried in stock and gradually worked off. To counteract this, contracts with various small producers were not renewed, and the mines were forced to shut down for lack of a market for their ore.

As seen in the foregoing table of smelter production, Alaska and Colorado had a greatly decreased production; Arizona and Washington a small percentage of increase, and Montana and California a very considerable increase. All the other states supplied less copper than in previous years.

The total combined 1918 output of refined copper from all sources amounted to 2,476,077,461 lb. compared with 2,507,663,067 lb. in 1917.

[1] *Eng. Min. Jour.*

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These figures include the so-called secondary copper, meaning resmelted or renovated metal, as contrasted with that derived from ore.

The United States continues to be the greatest producer of copper, yielding over 60 per cent. of the world's mine output and 75 per cent. of the output of refined copper.

Japan continues to be the world's second largest producer, but its output of 95,800 tons in 1918 was 15,456 metric tons less than in 1917. Chilean mines yielded 85,850 tons, only 10,000 tons less than Japan, and there is little doubt that this country will soon be second only to the United States in its copper production. Mexican mines yielded 75,529 metric tons, which is an increase of nearly 60 per cent. over the 1918 figures and of 36 per cent. over the 1916 production, due largely to the bettered operating conditions at Cananea.

PRODUCTION OF REFINED COPPER BY REGULAR REFINERIES (*a*)
(In pounds)

	1913.	1914.	1915.	1916.	1917.	1918.
Primary (*b*):						
Domestic—						
Electrolytic...	1,022,497,601	991,573,073	1,114,345,342	1,579,620,513	1,452,744,593	1,560,327,422
Lake.....	155,715,286	158,009,748	(*c*) 236,757,062	269,794,531	268,508,091	231,096,158
Casting.....	22,606,040	21,506,325	21,555,129	12,469,050	69,916,911	15,284,635
Pig and best select.....	36,004,986	39,334,043	15,047,990	26,868,105	82,376,576	76,165,976
	1,236,823,913	1,210,423,189	1,387,705,523	1,888,752,199	1,873,546,171	1,882,874,191
Foreign (electrolytic).....	378,243,869	323,358,205	246,498,925	370,635,116	(*d*)555,000,000	(*d*) 492,181,364
Foreign casting and best select.....	.....	.....	.....	.....	.....	57,329,735
	1,615,067,782	1,533,781,394	1,634,204,448	2,259,387,315	2,428,546,171	[2,432,385,290
Secondary:						
Electrolytic.....	14,862,577	27,702,928	38,156,789	78,585,296	66,337,771	34,674,062
Casting.....	22,360,182	4,224,052	21,417,901	25,838,511	12,779,125	9,018,049
	37,222,759	31,926,980	59,574,690	104,423,807	79,116,896	43,692,111
Total output..	1,652,290,541	1,565,708,374	1,693,779,138	2,363,811,122	2,507,663,067	2,476,077,401

(*a*) U. S. Geol. Surv.
(*b*) The separation of refined copper into metal of domestic and foreign origin is only approximate, as an accurate separation at this stage of manufacture is not possible. (*c*) Some Lake copper was refined at seaboard plants and doubtless marketed under some brand other than Lake. This has been excluded from the Lake copper. (*d*) Includes refined copper imported.

Canadian production is officially reported to be 57,652 metric tons (118,418,829 lb.), an increase of 8.4 per cent. in quantity, but decreased total value, owing to the lower price fixed by the Government. In Cuba, successful developments in the western province offset the decreased production of Santiago; the output of 12,337 tons for 1918 was 2000 tons greater than that of the previous year.

There are eleven electrolytic refineries in the United States treating converter copper. There are also several plants, notably that of the

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New Cornelia Co. at Ajo, Ariz., and that of the Anaconda Copper Co. in Montana, producing electrolytic copper direct from solutions made from ore. The many plants commonly called refineries, that treat scrap copper and old metal exclusively, are of course not included, and their product is the so-called "secondary copper" of the U. S. Geological Survey reports on secondary metals.

The resmelted copper turned out by these plants in commercial forms and as brass and other alloys amounted to 37,903,934 lb. in 1918, compared with 41,821,811 lb., in 1917, and 37,380,759 lb. in 1916. This amount is included in the total 1918 copper output of the smelters of 2,255,063,895 lb., compared with 2,277,859,962 lb. in 1917. These figures include also copper derived from ore coming from outside of North America.

Summarizing the year's production, it is evident that the acceleration of production by high prices and insistent demand, which stimulated and broadened this industry in 1917, was followed by decreased development of new properties, though the great mines of the country continued to increase their output as a patriotic duty, despite a more than 100-per cent. increase in cost, and the grossly unjust price fixed by the Government War Trade Board. Governmental statistics show that although the United States yields 60 per cent. of the copper production of the world, fully one-third of this country's output comes from six companies and of these six, the so-called "porphyry coppers" have a definitely limited life, which varies from 15 to 25 years. More than half the North American supply comes from 7 per cent. of the operating companies. Under these circumstances there is good reason to fear an actual copper shortage, should consumption continue to increase at the same rate it did before the war.

A matter of vital importance to the copper mining industry was the organization of the Copper Export Association, Inc., organized Dec. 17, 1918, with capital of $250,000 in 7 per cent. preferred stock and 500 shares common. This association includes 75 per cent. of the copper producers and probably 95 per cent. of the annual output. It is not intended as a profit-making concern, but acts as a broker and to apportion all foreign orders, pro rata, based on the production of the various companies for the previous 12 months. Each member receives one share of stock, which has neither market nor par value and no voting privilege. One vote is given to each 500 tons of copper allotted for export. The executive committee includes Simon Guggenheim, chairman of the board, John D. Ryan, president, Walter Douglas, vice-president, R. S. Agassiz, vice-president, and Wm. A. Clut, Adolph Lewisohn, Jas. McLean, Murray Guggenheim, Jas. McNaughton, and Cornelius Kelly, directors.

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Consumption

The part played by copper in the war is clearly brought out by the table below showing American consumption and exports in the last 10 years in pounds. It is of interest to know that shipments of American copper to our allies in 1917—well over a billion pounds—were more than the total smelter production of this country no longer ago than 1911. In 1913 domestic consumption and our shipments to foreign countries about offset each other, with Germany our largest customer. In 1914, with its disturbance to all lines of American industry, our absorption of the metal was only 620,000,000 lb., or less than one-half the meltings in 1916 and 1917. Now home consumption and exports are about equal, with Germany, of course, eliminated from the list of export customers.

It should be remembered that the supply to manufacturers was curtailed during the year, and not only was war work given the preference, but in effect all other work was greatly curtailed if not suspended.

A copper surplus of between 1,000,000,000 and 1,800,000,000 lb. was reported on Jan. 1, 1919, largely as a result of the continuance of mining operations after the armistice of Nov. 11, under agreement with the War Board.

CONSUMPTION OF NEW REFINED COPPER IN THE UNITED STATES

Year.	Production.	Stock Jan. 1.	Supply.	Exports.	Stock Dec. 31.	Consumption.
1909	1,405,403,056	122,357,266	1,527,760,322	682,846,726	141,766,111	703,147,485
1910	1,452,122,120	141,766,111	1,593,888,231	708,316,543	122,030,195	763,541,493
1911	1,431,938,338	122,030,195	1,553,968,533	786,553,208	89,454,695	677,960,630
1912	1,581,920,287	89,454,695	1,671,374,982	775,000,658	105,312,582	791,061,742
1913	1,622,456,829	105,312,582	1,727,769,411	926,441,142	91,348,867	709,979,402
1914(a)	1,533,781,394	90,385,402	1,634,166,796	840,080,922	173,640,501	620,445,373
1915(a)	1,634,204,448	173,640,501	1,807,844,949	681,917,955	82,429,666	1,043,497,328
1916(a)	2,259,387,315	82,429,666	2,341,816,981	784,006,486	128,055,229	1,429,755,266
1917(a)	2,428,546,171	128,055,229	2,556,601,400	1,126,082,417	114,000,000	1,316,518,983
1918(a)	2,432,385,290	114,000,000	2,546,385,290	b)704,715,714	180,000,000	1,661,669,576

(a) U. S. Geol. Surv. (b) Exclusive of manufactured copper.

Exports

During 1918, exports of refined copper as ingots, bars, plates and wire, etc., amounted to 744,429,803 lb. To this must be added the exports of copper ore, regulus and matte, sent to foreign smelters and refineries, amounting to 3,259,839 lb. This does not include the copper in brass and other alloys sent abroad, which appears as domestic consumption.

The following table, which shows exports to different countries for the past 6 years, shows very conclusively that before the war the heavy buying of Holland, Belgium and Denmark was largely for German orders, and together with German and Austrian purchases amounted to five-eighths of the total amount shipped abroad in 1913.

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During 1918, the copper export business was regulated by the War Industries Board, under the Government's fixed maximum price with apportionment to each country as deemed best by the Board. Exports for 1918 averaged 62,300,000 lb. per month.

EXPORTS OF COPPER FROM THE UNITED STATES
(In pounds)

Country.	1913.	1914.	1915.	1916.	1917.	1918.
Ore and matte (a)	147,132,160	97,504,960	129,317,440	5,784,768	5,957,295	3,259,839
Refined ingots, bars, etc. Exported to:						
United Kingdom	33,679,641	198,382,459	201,218,655	173,003,875	372,743,338	251,805,814
Belgium	7,102,120	5,429,717	.....	.....	.....	.....
France	160,000,345	150,839,897	236,236,135	318,136,643	366,231,608	265,270,793
Germany	307,150,761	176,698,948	.....	.....	.....	.....
Italy	41,568,713	67,415,944	107,101,156	98,249,149	152,997,819	121,907,864
Netherlands	178,940,289	126,001,150	4,018,841	.....	.....	.....
Russia	7,907,672	8,731,272	37,430,402	56,777,486	75,037,925	.....
Austria-Hungary	34,648,205	26,989,548	.....	.....	.....	.....
Other Europe	14,357,014	45,634,229	56,013,517	.....	.....	.....
Canada	36,182,257	24,221,498	24,127,098	41,900,063	49,867,577	33,087,082
Other countries	4,904,125	9,736,260	15,771,151	28,549,547	13,901,061	17,956,400
Total refined	826,441,142	840,080,922	681,917,955	716,616,763	1,030,779,328	690,027,953
Blister and black	(b)	(b)	(b)	18,263,118	16,992,357	14,687,823
Alloys	(b)	(b)	(b)	(c)	(c) 1,228,032	186,260
Old and scrap	(b)	(b)	(b)	815,825	1,070,389	257,403
Pipes and tubes	(b)	(b)	(b)	(c)	(c) 7,260,833	4,109,226
Plates and sheets	(b)	(b)	(b)	24,843,435	(c) 42,664,943	19,471,584
Wire, not insulated	(b)	(b)	(b)	23,467,345	26,879,498	15,689,554
Grand total	.....	.....	.....	789,791,254	1,132,832,663	747,689,642

(a) Until 1916 the exports of ore and matte are reported as gross weight, the copper contents not being stated. (b) Included in "Refined ingots, bars, etc." (c) Not separately listed until July 1, 1917.

Imports

Imports of copper into the United States consist almost entirely of material sent for treatment, mainly electrolytic refining. The figures include some copper ore sent to our smelters as well as copper matte for bessemerizing, and refining, and pig copper from the big smelting works of Canada, Mexico, Peru, Chile, etc.

Imports of copper in 1918 in unconcentrated ore total 76,872,013 lb. net, compared with 116,500,532 lb. in 1917; in concentrates, 46,267,874 lb., compared with 38,197,532 lb. in 1917; in matte, 34,076,594 lb., compared with 21,048,943 lb. in 1917. Ore shipments came from Cuba, Canada and Mexico, with some from South America. The shortage of ships practically stopped imports from Spain, Portugal and Japan.

Imports of the metal as converted pigs, ingots, bars and scrap for 1918 amounted to 418,588,634 lb., compared with 380,673,290 lb. in 1917, and 287,548,126 lb. in 1916.

The table following gives the annual imports into the United States from other countries.

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IMPORTS OF COPPER INTO THE UNITED STATES (a)

(In pounds)

Country.	1913.	1914.	1915.	1916.	1917.	1918.
Ore and matte. Imported from:						
Germany	1,067,024	4,684,448	.....	.....	.....	.....
Spain	6,244,676	2,633,395	1,278,403	2,659,211	371,902	.....
Cuba	5,362,132	18,659,788	28,876,226	40,644,140	45,343,462	28,716,903
Canada	34,072,096	24,584,124	29,591,823	37,344,754	31,134,172	31,718,784
Mexico	19,722,530	15,495,694	14,707,724	33,525,559	40,168,291	64,879,683
Chile	25,311,542	30,562,839	33,435,039	44,508,322	43,906,869	18,947,068
Other countries	17,712,105	8,180,816	6,442,226	16,105,868	14,822,411	12,954,023
Total	109,492,105	104,801,324	114,331,441	174,787,854	175,747,107	157,216,481
Blister and black. Imported from:						
United Kingdom	17,943,285	5,163,126	7,485,625	1,554,649	.....	112,738
Other Europe	(d) 36,565,767	(d) 16,931,784	(d) 7,964,534	(d) 550,290	.....	.....
Canada	33,749,133	27,230,559	44,977,829	47,951,823	40,571,204	37,881,986
Mexico	97,003,847	43,193,868	15,973,838	61,756,926	40,213,831	83,568,187
Chile	18,315,000	23,814,659	36,303,505	70,762,349	162,227,104	156,285,580
Peru	42,667,436	44,488,809	61,342,067	72,827,909	100,302,275	81,492,209
Australia and Tasmania	22,149,335	15,130,001	443,520	.....	.....	.....
Japan	14,367,493	10,918,069	17,970,768	9,192,010	6,393,524	827,404
Other countries	17,298,533	14,678,628	8,905,322	4,331,359	5,890,018	18,203,547
Total (b)	300,059,829	201,549,503	201,367,008	268,927,315	355,598,036	378,371,651
Refined ingots, bar, etc.	(c)	(c)	(c)	8,411,230	6,751,958	38,087,769
Scrap and old	(c)	(c)	(c)	9,451,388	17,893,594	1,921,539
Alloys	(c)	(c)	(c)	758,193	429,702	207,675

(a) The imports reported are the copper contents of ore, matte, and regulus. (b) Includes also refined, scrap, etc., until 1916. (c) Included in "Blister and black." (d) All from Spain.

World's Production

The world's total production of copper for 1918 is not very different from that of the previous year, the decrease below the 1917 total being less than 3 per cent. Mexico showed a 50-per cent. increase, while Canada, Cuba and Chile also furnished somewhat more than in 1917. As will be noted in the table, the more remote countries, Australia, South Africa, and Japan, showed decreases, owing in part to limited shipping capacity.

The copper production of the various countries of the world is summarized in the following tables, the figures being mainly those of the *Engineering and Mining Journal*, supplemented by those of the *Mines Handbook*.

The Japanese production is given as 95,800 tons. When the decreased exports from that country are considered, a decrease amounting to 31,950 tons for the first 8 months of the year, there is indicated an increased stock held there. A similar but less notable condition exists in Spain and Australia.

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THE WORLD'S COPPER PRODUCTION
(In metric tons)

Country.	1910.(h)	1911.	1912.	1913.	1914	1915.	1916.	1917.	1918.
Africa (a) Cape Co.	7,016	17,252	16,63	5,812	3,125	d27,327	(d)34,572	45,138	31,110
Africa (a) Namaqua				2,540	2,328				
Africa (a) Other	8,433	.....	.....	17,059	18,682				
Argentina (a)	305	1,036	335	117	.....	.....	.....	.....	.....
Australasia (a)	40,962	42,512	47,774	47,326	37,590	32,512	(d)35,000	(d)38,100	33,838
Austria-Hungary (a)	2,276	2,566	4,024	4,135	3,310	.....	.....	.....	.....
Bolivia (a)	2,540	(d) 2,950	(d) 4,681	3,658	2,743	*3,000	*4,000	*4,000	*4,000
Canada (d)	23,810	25,570	34,213	34,587	34,027	47,202	47,985	50,626	52,693
Chile (d)	38,346	33,088	39,204	40,195	40,876	(f)52,081	(f)71,430	83,100	85,850
Cuba (d)	3,538	3,753	4,393	3,517	6,251	8,836	7,816	10,313	12,337
Germany—total (a)	25,105	22,363	24,304	25,309	30,480	*35,000	*45,000	*45,000	*40,000
(Mansfeld) (a)	(20,275)	.....	.....	(20,201)	.....	.....	.....	.....	.....
Italy (a)	3,272	2,642	2,337	1,626	2,410	(f)1,840	(f)1,867	.. (f)1,331	.....
Japan (f)	50,703	(d)52,303	(d)62,486	(a)73,152	68,058	75,415	81,280	111,256	95,800
Mexico—total (d)	62,504	61,884	73,617	52,815	36,337	30,969	55,128	47,503	75,529
(Boleo) (a)	(13,003)	.....	.....	(13,020)	.....	.....	.....	.....	.....
Newfoundland (a)	1,097	1,174	549	.....	.....	.....	.....	.....	.....
Norway (a)	10,592	9,576	11,156	11,796	*11,000	*11,000	*6,000	.....	.....
Peru (c)	27,375	28,500	(f)26,483	(d)25,715	23,647	(d)32,410	(f)41,625	45,620	44,800
Russia (c)	22,670	25,747	33,550	42,970	31,938	(d)25,881	(d)20,877	*16,000	*5,000
Spain-Portugal (a)	51,080	51,748	59,876	54,696	37,099	*46,200	*42,000	*42,000	*41,000
Rio Tinto (a)	(34,114)	(35,100)	.....	36,901	21,515	.....	.....	.....	.....
Tharsis (a)	(3,551)	(3,450)	.....	3,270	.....	.....	.....	.....	.....
Mason & Barry (a)	(3,003)	(2,972)	.....	3,185	.....	.....	.....	.....	.....
Sevilla (a)	(1,656)	(1,558)	.....	1,535	.....	.....	.....	.....	.....
Sweden (c)	2,032	2,032	3,957	6,891	4,692	4,561	3,181	4,423	.....
Turkey (a)	610	1,016	508	508	.....	.....	.....	.....	.....
United Kingdom (f)	508	405	405	305	347	238	282	.....	.....
United States (d)	492,720	491,634	563,260	557,387	525,529	646,212	881,237	872,065	848,203
Total	877,494	879,751	1,011,312	1,002,284	934,888	1,094,803	1,408,280	(i)1,435,721	(i)1,395,160

(a) As reported by Henry R. Merton & Co., Ltd., of London until 1914. (c) As officially reported. (d) As reported by the *Eng. Min. Jour.* (f) As officially reported. (h) Henry R. Merton & Co., through *Eng. Min. Jour.* (i) Includes 25,000 tons estimated production of other countries.
*Estimated.

WORLD'S PRODUCTION OF COPPER (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1885....	229,315	252,828	1897...	412,818	455,147	1909...	854,758	942,408
1886....	220,669	243,295	1898...	441,282	486,529	1910...	877,494	966,998
1887....	226,492	249,716	1899...	476,194	525,021	1911...	879,751	969,750
1888....	262,285	281,179	1900...	491,435	541,561	1912...	1,011,312	1,114,769
1889....	265,516	292,741	1901...	529,508	583,517	1913...	1,002,284	1,104,517
1890....	274,065	302,166	1902...	542,606	597,951	1914...	934,888	1,018,395
1891....	280,138	308,862	1903...	630,590	694,910	1915...	1,094,803	1,206,793
1892....	309,113	340,808	1904...	693,240	764,758	1916...	1,408,280	1,552,347
1893....	310,704	342,562	1905...	698,931	770,221	1917...	1,435,721	1,582,595
1894....	330,075	363,920	1906...	715,510	788,492	1918...	1,395,160	1,537,884
1895....	339,994	374,856	1907...	724,120	798,205			
1896....	384,493	423,917	1908...	758,065	835,623			

(a) The statistics for 1885–1891 are as reported by Henry R. Merton & Co.; 1892–1918 as per MINERAL INDUSTRY.

PRICES

Prices for 1918 were fixed in this country by the War Industries Board and for the British Empire by that Government. In the United States the price of 23½ cts. fixed by our War Board, Sept. 6, 1917, was continued until July 2, 1918, when it was raised to 26 cts. Both prices were unsatisfactory to the producing companies and were considered unfair to the small producers, whose costs of production rose so high

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that profits were wiped out. Many small mines, which had started production under the stimulus of the high prices of 1917, which varied from 28½ to 37 cts. per lb., were unable to pay expenses and were forced to shut down. The sudden advance made in July to 26 cts. was more than offset by coincident increases in wages, governmental advances in freight rates, and increased refining and smelting charges, so that producers were actually worse off than before the advance. This experience proved a lesson to the copper producers that governmental control is not an unmixed blessing.

As stated in last year's review, all sales were made nominally through a Copper Producers Committee, but actually through the United Metals Selling Co. for all United States orders, and all foreign orders through the American Smelting & Refining Co. Domestic orders were filled and billed by individual producers in the old way, but at the Government's fixed price of 23½ cts. (and after July 2, 26 cts.) f.o.b. New York, cash basis, plus freight.

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK (a)
(In cents per pound)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1907.	24.404	24.869	25.065	24.224	24.048	22.665	21.130	18.356	15.565	13.169	13.391	13.163	20.004
1908.	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.208
1909.	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910.	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911.	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912.	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913.	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	15.269
1914.	14.223	14.491	14.131	14.211	13.996	13.603	13.223	(b)	(b)	(b)	11.739	12.801	13.602
1915.	13.641	14.394	14.787	16.818	18.506	19.477	18.796	16.941	17.502	17.686	18.627	20.133	17.275
1916.	24.008	26.440	26.310	27.895	28.625	26.601	23.865	26.120	26.855	27.193	30.625	31.890	27.202
1917.	28.673	31.750	31.481	27.935	28.788	29.962	26.620	25.380	25.073	23.500	23.500	23.500	27.180
1918.	23.500	23.500	23.500	23.500	23.500	23.500	25.904	26.000	26.000	26.000	26.000	(c)	24.628

(a) From *Eng. Min. Jour.* (b) No quotation. (c) No market.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES (a)
(In cents per pound)

	1916.		1917.		1918.	
	Wire.	Sheet.	Wire.	Sheet.	Wire.	Sheet.
Jan.	25.70	31.00	37.00	42.00	26.50	31.50
Feb.	28.66	34.50	37.00	42.12	26.56	31.50
Mar.	29.13	34.50	38.11	43.00	26.43	31.50
Apr.	31.10	36.00	38.20	42.20	26.50	31.50
May.	33.75	37.88	36.56	40.30	26.62	31.50
June.	32.50	38.00	35.00	38.75	26.64	31.90
July.	30.25	38.00	34.12	38.22	29.50	34.25
Aug.	31.38	37.00	32.85	36.85	29.50	34.50
Sept.	32.00	38.00	31.00	35.00	29.50	35.00
Oct.	32.35	38.00	31.00	35.00	29.75	35.25
Nov.	35.56	40.37	28.83	33.17	29.00	35.60
Dec.	37.00	42.00	26.84	31.74	27.70	35.65
Year.	31.61	37.10	33.87	38.19	27.85	33.30

(a) *Eng. Min. Jour.*

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AVERAGE PRICE OF STANDARD COPPER (G. M. B.'S) IN LONDON (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1907.....	106.739	107.356	106.594	98.625	102.375	97.272	95.016	79.679	68.375	60.717	61.226	60.113	87.007
1908.....	62.386	58.786	58.761	58.331	57.387	57.842	57.989	60.500	60.338	60.139	63.417	62.943	59.902
1909.....	61.198	57.688	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732
1910.....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911.....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912.....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	72.942
1913.....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	68.355
1914.....	64.304	65.259	64.276	64.747	63.182	61.336	60.540	(b)	(b)	(b)	53.227	56.841	61.524
1915.....	60.756	63.494	66.152	75.096	77.600	82.574	76.011	68.673	68.915	72.601	77.744	80.773	72.532
1916.....	88.083	102.667	107.714	124.319	135.457	112.432	95.119	110.283	113.905	122.750	134.659	145.316	116.029
1917.....	131.921	137.895	136.750	133.842	130.000	130.000	128.409	122.391	117.500	110.000	110.000	110.000	124.892
1918.....	110.000	110.000	110.000	110.000	110.000	110.000	119.913	122.000	122.000	122.000	122.000	118.447	115.530

(a) From *Eng. Min. Jour.* (b) No quotation.

Costs

The 1918 cost of producing a pound of copper increased 50 to 100 per cent. over the normal pre-war figure. The greatest single item in this increase was labor, whose wage was at first arbitrarily maintained at the figure based on 35-ct. copper prices and later still further advanced. Not only was the wage high but the labor became inefficient. Increased freight rates were nominally 25 per cent. higher, but were actually 100 per cent. higher, as disclosed in a suit brought by the Phelps-Dodge and other companies against the Director General of Railroads, showing an increase from $8.55 rail and water rates to New York to $16.50 per ton, with marine insurance added.

The extent of the increase in the cost of producing a pound of copper can best be shown by a comparison of costs of four big companies, Utah, Ray, Chino and Nevada Consolidated, all under one general management, for 1918.

	Cents per Pound.	
	1916.	1918.
Utah	6.91	16.30
Chino	8.70	17.20
Ray	10.26	18.05
Nevada Consolidated	8.67	18.87
Anaconda	9.50	15.00
Chile Copper	15.46	13.50
Inspiration	8.67	11.00
Greene Cananea	11.35	16.00

It is noteworthy that costs of low-cost North American producers advanced more in proportion than those of high-cost producers.

The detailed costs and other operating data of each of the big "porphyry" mines is shown in the table.

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1918 Operations.	Utah Copper.	Chino.	Ray.	Nevada Cons.	Miami.	Inspiration.
Tons of ore milled	12,160,700	3,836,400	3,411,000	3,999,526	2,132,941	5,110,101
Tons of ore milled per day	16,658	10,510	9,345	.....	5,925	14,172
Average copper content of ore, per cent	1.226	1.63	1.613	1.506	2.026	1.36
Average copper content of concentrates, per cent	16.083	14.25	18.198	8.33	40.147	30.398
Total pounds of copper produced	197,978,557	79,340,372	86,919,270	76,607,062	58,407,563	98,540,041
Pounds of copper recovered per ton of ore	16.23	20.676	24.17	.....	28.82	19.08
Extraction, per cent	65.11	63.275	74.92	67.28	71.15	72.99
Average milling cost per ton	$92.77	$1.37	$1.01	$0.93	$0.72	.....
Average cost of copper per pound, cents	16.331	17.178	17.695	16.60	14.833	11.259
Ore reserves, tons	374,040,000	95,580,737	86,383,642	68,549,644	54,570,000	.....
Copper tenor of ore reserves, per cent	1.370	1.63	2.061	1.57	1.467	.....
Dividends paid	$12,589,797	$2,827,435	$5,125,832	.....	$3,362,013	$9,455,736
Added to earned surplus	$2,303,615	$6,688	*$472,376	.....	.....	.....
Charged off for depreciation	$979,450	$375,067	.....	.....	$573,974	$750,000

* Decrease.

Copper Mining in the United States

The table already presented summarizes the production of each of the copper-producing states and shows that Arizona furnishes 49 per cent. of the country's copper production and Montana yields over 17 per cent., Utah and Michigan being respectively the next largest producers, the four States producing 82.2 per cent. of the total output. The copper industry is peculiar in that it has relatively few big producers and many small and comparatively insignificant mines.

Alaska.—The 14 operating copper mines of Alaska produced 720,000 tons of ore, yielding 69,426,000 lb. of copper valued at $17,180,000. Three mines active in 1917 were inactive in 1918, and the total output was 60,000 tons of ore less, and 19,393,000 lb. of copper less than in 1917. Most of the copper, about 90 per cent. in fact, came from the mines owned or controlled by the Kennecott Copper Corporation.

Copper River Region.—The four producing copper mines of this district include the Kennecott & Bonanza, the most noted Alaskan copper mine, yielding the richest copper ore mined in the world; the Jumbo, Mother Lode and Nugget Creek (Alaska Copper Corporation) also operated, the last in a small way only.

The Kennecott, Bonanza, Jumbo and Mother Lode mines lie east of the Kennecott glacier, at an elevation of about 6000 ft. above sea-level, and above the town of McCarthy, the terminus of the Copper River railway, a 175-mile road, built and maintained expressly for these copper mines. The ore is solid glance and occurs in limestone, above the greenstone contact. The orebody is wide, occuring primarily in a vertical fault system, but the great orebodies are at the intersection of the vertical and

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flat or bedding-plane faults, forming large tabular masses replacing limestone.

At the Jumbo mine, the orebody is 240 ft. wide, and extends from 30 ft. above the 400-ft. level almost to the 600-ft. level, one lens yielding 50,000 tons of 76-per cent. ore.

At the Mother Lode mine, the same rich ore occurs in the limestone far above the greenstone contact. All the mines contain some oxidized ore.

The Kennecott-Bonanza mines were operated throughout 1918, though scarcity of labor and a short shut-down due to tram trouble reduced production 75 per cent. for three-fourths of the year. The incline Bonanza shaft was deepened to 800 ft.; much new development was done on the 600-ft. level and on the new level opened at 700 ft.

The Erie mine, operated until Aug. 10, was shut down on that date. At the Jumbo a new two-compartment incline shaft was sunk to the 500-ft. level.

At the mill, the ammonia-leaching plant has been enlarged and now handles all tailings of carbonate ore from the concentration mill, with an extraction of 75 per cent. of the 17-lb. average copper content of the tailings.

The Mother Lode workings are now connected with those of the Bonanza and the mine is operated under control of the Kennecott company. During 1918 mine development included 2500 ft. of new work in the Rhodes level. The Westover mine shipped some ore during the first part of the year, as did the North Midas Copper Co., though the latter company's output was gold ore.

Prince William Sound.—In the Prince William Sound region, four producing copper mines yielded 15,000,000 lb. of the metal, containing over $700,000 gold and silver. Most of this came from the Beatson-Bonanza mine of the Kennecott Copper Co., where a new power plant permitted driving a new level 300 ft. below the main level and the development of the 200-ft. level, where a 500-ton pocket was cut. The mill was enlarged to handle 1500 tons daily and the ore-bins in the docks to hold 5500 tons.

The Ellamar mine in the same district was continuously operated, though on a reduced scale, due to the shortage of labor and steamers. Development only was done in the winter at the Midas when, ore shipments being impossible, all work save diamond drilling was stopped. Shipments were resumed from April to September.

Ketchikan District.—In southeastern Alaska the Ketchikan district produced 1,780,000 lb. of copper and $42,000 in gold and silver, from the It, Jumbo, Rush & Brown, Mamie, Rich Hill (of the Granby Co.)

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and Salt Chuck (or Goodro) mines. The last named continued to operate the 60-ton concentration mill with satisfactory results; the ore is remarkable because of its palladium content. The total output of the six operating mines was only half that of 1917.

Arizona.—Arizona maintained its supremacy as the world's greatest copper-producing region, the output being 40 per cent. of that of the entire country, and showing an increase of over 50,000,000 lb. for the year. The mine output of copper was 764,855,874 lb., an increase of 52,688,983 lb. over the 712,166,891 lb. for 1917. This increase was largely due to the completion and operation of the United Verde Extension smelter at Verde, to the enlarged operation of the Ajo leaching plant, and the operation of the International smelter at Miami.

The enormous production of the State has been attained at the cost of development and exploration in the mines and the proper maintenance of mechanical equipment. The year showed no new producers of any considerable magnitude.

Of notable general interest, the systematic drilling and stripping of the Copper Queen ground at Bisbee and the starting of similar operations by the United Verde at Jerome may be mentioned. No sensational discoveries of new orebodies have been made and no new camps developed, though the deposits in schistose rocks at the Kay mine, north of Phoenix and the mines near Mayer, have responded well to development work.

Ajo District.—This district has had its first year of full production by the New Cornelia Copper Co. at Ajo, the mine output averaging 5000 tons of carbonate ore per day. The New Cornelia orebody is a monzonite intrusive in Tertiary rhyolite. This rock is altered and peppered with pyrite and chalcopyrite with some bornite grains. The ore deposit is oxidized but not leached or impoverished for 100 ft. or so below the surface, while the underlying material is not secondarily enriched (except locally). The reserves of this carbonate ore on Jan. 1, 1919, were 10,100,985 tons of 1.568-per cent. ore. The underlying body of sulphide ore is as yet but partly explored, but diamond-drill work has proven 40,302,457 tons of 1.587-per cent. ore. Construction work on a new 500-ton experimental plant thoroughly to test milling of this sulphide ore, was begun in December, 1918. The oxidized ore is mined by three steam shovels operating for 16 hr. each day, and loading into trains of six 50-ton cars to be hauled 1½ miles to the crushing plant, where by various stages it is reduced to fragments ¼ in. across. This material is treated in 12 leaching tanks, 9 of them always in operation, one being filled, one excavated and emptied and one washed, the circuit taking 6 to 8 days. Improvements to the plant in 1918 include an additional

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crushing unit, a fourth motor-generator set, a second 800-gal. pump and other machinery to preclude a lessening of output by breakdown. The total output of the company for 1918 was 49,950,139 lb. of copper, comprising 31,264,642 lb. of cathode plates, 10,990,066 lb. as cement copper shipped and 4,694,831 lb. in ore shipped.

Ore reserves also comprise 41,219,437 tons of sulphide ore averaging 1.587 per cent. copper, but this figure is low because a number of diamond-drill holes are bottomed in ore. It is evident that the mine will soon need a mill sufficient to handle 5000 tons of sulphide ore per day, amenable to flotation.

Bisbee District.—The two big companies, the Phelps-Dodge Corp. and the Calumet & Arizona, continued operations without any apparent exhaustion of mines. The production of the Bisbee mines of the Calumet & Arizona for 1918 was 49,432,984 lb., compared with 59,131,512 lb. in 1917, while the smelter output, treating New Cornelia and also custom ores, was 83,442,652 lb. of copper, 32,682.35 oz. of gold and 1,109,411 oz. of silver, in addition to returns of 1,848,568 lb. of copper, 2107.5 oz. of gold and 560,693 oz. of silver from 60,733 tons of sulphide ore mined.

Ore was opened up and mined at the several shafts of the Calumet & Arizona Co., but the sinking of the new Campbell shaft was suspended until labor becomes more plentiful. The ore developed exceeded the amount mined, so reserves are intact. The company is still developing the Gadsden property at Jerome, thus far without the discovery of any orebody, though the shaft is 1230 ft. deep and the 1200-ft. crosscut runs west for 1100 ft. It is expected to reach the Jerome fault at 1600 ft. from the shaft.

At the four main operating mines of the company known as the Oliver, Junction, Briggs, and Cole shafts, development work during 1918 aggregated 54,675 ft. of drifting and 28,398 ft. of raises and winzes, besides 16,281 ft. of diamond-drill work in the Junction and Briggs mines. At the Junction, which continued to be the company's main shaft, the 1600-ft. level was driven south, and the 1400- and 1600-ft. drifts were extended to the Denn line.

At the Cole shaft, the Sunnyside orebody on the 900-, 1000- and 1100-ft. levels furnished the bulk of the output. At the Briggs, exploratory development was limited mainly to the known orebodies. The Irish Mag mine was worked by leasors, who mined 2484 tons of 3.57-per cent. ore. The total ore mined in 1918 was 576,888 dry tons.

The new work at the C. & A. mines, outside of the known orebodies, comprised extensions of the 1400- and 1600-ft. levels to develop territory adjacent to the orebodies lately developed in the Denn mine, work that is in new territory and 2000 ft. from the orebodies now worked. The

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company's actual ore reserves were increased during the year and the percentage of oxidized ore is becoming less and less.

At Courtland, where the company owns a very considerable acreage of mining ground, leasors mined 1224 tons of ore.

The Copper Queen mines, a branch of the Phelps-Dodge Corp., continue to dominate the Bisbee district. As noted elsewhere in this review this corporation owns the Detroit Copper Co.'s mines at Morenci, the Burro Mountain mines, New Mexico, the Moctezuma mine at Nacozari, Sonora, the United Globe and Old Dominion mines at Globe, and the Copper Basin mine, a producing property near Prescott. The Bloggs and the Hackberry mine near Mayer, the Yucca and Copper World mine, near Prescott, and the Senator and Snoozer mines also belong to this company.

At the Copper Queen the most important new work of the year was the beginning of preparations at the Sacramento Hill area for mining. This hill is formed by a small granite porphyry stock intrusive in limestone. The mines which have made the district famous for so many years are grouped about its north, west and southern sides, these mines now yielding a daily output of 4000 tons of ore. Diamond-drill work has shown that the porphyry mass contains 15,000,000 tons of 1½-per cent. copper ore in two orebodies, the East and West, which are separated by a barren strip 400 to 500 ft. wide. The west orebody has 6,000,000 tons of 2-per cent. ore. To mine this involves the removal of 15,000,000 tons of waste forming the capping over the ore and it will take two years' work to strip it in three benches, one 60 ft. above the other. A new mill to treat this ore will be erected, two miles south, and a half mile southwest of Warren; work on the mill site was begun in 1918.

The Shattuck Arizona Copper Co. mined 93,967 tons of copper ore in 1918, besides 29,277 tons of lead ore.

Development work to January 1, 1919, was 15,125 ft. on nine levels, but little new work being done during the year. The output averaged 820,132 lb. of copper monthly for the first 8 months. The mill put up by the company to treat low-grade lead ore was completed and began operating July 1, 1918. Both the copper and lead output of the company shows a marked decline over previous years and it is evident that the big bodies of rich oxidized ore are exhausted. The underlying sulphide, which occurs in large amount, though low in copper content, will eventually be made to yield a profit.

The gross income for the year was $2,666,082 and costs $1,883,424.

Clifton-Morenci District.—The three operating companies continued production on a normal scale throughout the year. The Phelps-Dodge mines produced 465,807 tons of ore yielding 17,127,369 lb. copper. Very

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little development work was done during the year as every effort was put into producing a maximum tonnage. A general resampling and recalculating of ore reserves is now in progress. Due to the small amount of development work done, the mining cost per ton fell somewhat below the 1917 figure. During the year additions were made to the flotation equipment and the change from gas-engine to electrical drive was completed, giving the mill a much more dependable and economical form of power. Smelter operations were irregular throughout the year on account of a shortage of material. The costs for 1918 were somewhat higher than for the year previous, due in part to the increased cost of labor and coke, and in part to the increased silica content of the charge resulting from a higher ratio of coarse silicious ores to concentrates than has been treated in the past. The installation of two Diesel engines in the power plant early in the year allowed the discarding of the old gas engines at the power house and mill, and effected a very decided improvement in the power situation, both as to economy and reliability.

The Arizona Copper Co., Ltd., a Scotch corporation, controls the Humboldt, Coronado and other mines with 4000 acres of the mineral belt of the Clifton-Morenci district. The resumption of work after the long and bitter strike that kept the mines idle in the latter part of 1917 was necessarily slow, owing to the shortage of labor. Beginning with a production of but 2,500,000 lb. in January, 1918, the output increased to 3,600,000 lb. for February and 4,000,000 lb. for March. The total production for the year was 46,420,700 lb. During the fiscal year ending Sept. 30, 1918, the company mined 1,095,568 tons of ore that yielded 35.08 lb. per ton. Prospecting with two churn drills was carried on in the promising but wholly unprospected area east of the Coronado tunnel. Armstrong drills good for 1500 ft. and equipped with 25-hp. motors are used and 16 sites have been prepared for drilling. During the year, the Morenci concentrator treated 935,861 tons of 2.36-per cent. ore. Improvements at the Morenci No. 6 mill increased its capacity from 2800 to 4000 tons of ore daily. The increase has been effected by the installation of two Symons disc crushers, the elimination of jigs, the installation of a new floor of tables, the construction of additional large settling tanks, and very large Dorr thickeners for dewatering the tailings as well as the concentrates. To conserve as much water as possible, fresh water is pumped six miles against a considerable head and since it requires approximately 450 gal. of fresh water per ton of ore to sluice the tailings down the canyon, that amount of water must be added to the mill heads.

A noteworthy feature of the concentrator is the dust-catching system in the crushing division. Gyratory, disc crushers, and rolls for reducing 4000 tons of mine-run to ¾-in. size are housed in and connected to an

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exhaust fan, which delivers the dusty air to a centrifugal dust catcher. The solids are sprayed with water while circulating through the catcher, and the separation is so nearly complete that little dust can be observed in the exhaust. The atmosphere in the crushing division itself is very clear, and the installation may be said to have solved the dust problem in the dry crushing plant.

A 100-ton experimental mill is being installed in a building formerly used as a crushing plant before the new main hoisting shaft was sunk. In this plant methods will be studied of concentrating low-grade sulphides containing in the neighborhood of 1 per cent. copper, which the company possesses in very large quantity. The first trials will be on floating the finely ground eject from a Marcy mill, with table cleaning of the flotation tailing.

Globe District.—The Old Dominion Co. continues to be much the largest producer of the Globe district, its mines yielding 72,588 tons of direct smelting ore, 153,166 tons of milling ore and 4697 tons of converter ore, a total of 230,451 tons that averaged 4.52 per cent. copper, compared with 4.97 per cent. in 1917, 5.88 in 1916, and 6.56 in 1915. Development work for the year totals 22,163 ft., of which 10,477 ft. was drifting. The amount of smelting ore developed between the 16th and 18th levels west was small and below the average in grade. The work on the east-side orebody was more satisfactory, particularly on the 17th and 18th levels where the ore is 20 to 25 ft. wide and averages 4½ per cent. copper.

Total metal production in 1918 was 33,378,158 lb. of copper, 184,982 oz. of silver and 5071 oz. of gold. Production in 1917 amounted to 32,365,798 lb. The company also handled custom ore, the total tonnage put through the mill being 226,998 tons of 3.9-per cent. ore, compared with 199,575 tons of 3.78-per cent. ore in 1917. The ore supply to the smelter was but 165,028 tons, compared with 198,568 tons the previous year. The reduced amount of direct smelting ore produced in 1918 was disappointing and this with the high costs, 22.6 cts. per lb. of copper produced, greatly reduced earnings. Pumping expenses continue heavy, as much as 11,500,000 gal. per day being handled, compared with a maximum of 4,898,393 gal. per day in 1917.

The Arizona Commercial Mining Co., often known as the Amster Co., had a prosperous year, producing 62,796 tons of 5.874-per cent. ore, of which amount 11,712 tons of smelting ore carried 10.268 per cent. copper. This compares with 39,702 tons of 6.153-per cent. ore produced in 1917. The 1918 yield was 6,076,303 lb. of copper, 15,980 oz. of silver and 830 oz. of gold. Development for the year amounted to 6729 ft., compared with 3545 ft. in 1917.

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The Iron Cap Co. continued operations, making shipments from orebodies whose ownership is claimed by its neighbor.

Miami District.—The Inspiration Consolidated Copper Co. operated continuously in 1918, but, due to a shortage of labor, at only slightly above 80 per cent. capacity. Production totaled 98,540,041 lb. at a cost of 11¼ cts. per lb., excluding depreciation and federal taxes. The production in 1917 amounted to 80,566,982 lb. at a cost of 10½ cts. In the concentrator 5,110,101 tons of ore was milled, with an average assay of 1.361 per cent. copper and a recovery of 72.99 per cent.

A 35-ton leaching plant has been built to experiment on the treatment of the oxidized ore. No development work for the purpose of increasing ore reserves was done during the year. To protect its fuel-oil supply the company purchased jointly with the Anaconda Copper Mining Co., owner of the International Smelting Co., a tract of 160 acres of oil-producing land in the Bakersfield district of California, a corporation known as the Arizona Oil Co. being formed. Between May 21, 1918, the time at which the transaction was completed, and Jan. 1, 1919, 392,622 bbl. of oil was produced.

The Miami Copper Co., showing larger production and earnings for 1918 than 1917, operated continuously at full capacity throughout the year and produced 58,407,563 lb. of copper at a cost of 14.83 cts. per lb., not including depreciation. The 1917 production was 43,863,699 lb. at a cost of 12.511 cts. per lb. The six sections of the mill treated 2,132,941 tons of 2.026-per cent. ore with a recovery of 71.15 per cent.

At the end of the year 45 per cent. of the original high-grade reserves of the property had been extracted. Up to date, however, mining has included a very considerable proportion of the lower-grade ore from the Captain orebody, which was also high in oxidized copper content. The remaining tonnage is much cleaner in this respect; for this reason and on account of its higher grade, a greater production of copper from the same tonnage can be looked for. A 100-ton experimental mill is operated jointly by the company and the Bureau of Mines, its main object being to discover a method of profitably handling the large tonnage of carbonate ore of this district.

In 1918 churn drilling on the low-grade orebody increased these reserves 8,000,000 tons. Ore reserves on Jan. 1, 1919, were: high-grade sulphide ore, 12,570,000 tons of 2.38 per cent. copper; low-grade sulphide ore, 36,000,000 tons of 1.06 per cent. copper; mixed sulphide and oxide ore, 6,000,000 tons of 2.00 per cent. copper.

The new No. 5 shaft has been sunk and concreted to its full depth of 930 ft. This provides a haulage level and ore pocket for the deepest ore at present known to exist on the property.

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Jerome District.—Three producing companies and continued prospecting at the Gadsden, Green Monster, Verde Combination and Jerome Verde and several lesser properties made the year a busy one in this district. The United Verde started extensive and far-reaching changes in 1918, and at the same time made a record production of 77,501,595 lb. of copper, 1,292,109 oz. of silver and 29,281 oz. of gold, compared with 71,726,634 lb. of copper, 1,223,311 oz. of silver and 29,230 oz. of gold in 1917. The amount unsold carried over Jan. 1 was 26,070,253 lb. compared with 20,000,000 lb. in the year before. The plans call for the removal of all overburden, buildings, etc., over the big orebody to permit removing the ore by open-cut work and steam shovels, as is done at Bingham and at the Chino mine.

The United Verde Extension mine continued production in 1918, at the same time continuing work on its 12,384-ft. tunnel, which will tap the orebody at the 1300-ft. level and will materially reduce costs. No prospecting was done in 1918 and no new orebody found. The new smelter was blown in on July 18 and treated 71,257 tons of company ore up to December 31, producing 23,229,335 lb. of copper. The total output for the year 1918 was 133,535 tons of ore, yielding 55,491,077 lb. of copper, 3046 oz. of gold and 503,739 oz. of silver, equivalent to an actual recovery of 407 lb. of copper (20.3 per cent.), 48 cts. gold and 4.18 oz. of silver per ton. Stock on hand January first was 20,860,622 lb. of copper. Copper sold in 1918 was 54,126,107 lb. at 24.145 cts.

The new smelting plant treating 1000 tons per day is a model one in every particular, and will enable the company to keep the record of 8.4 cts. per lb. for copper, making it the world's cheapest copper producer.

During 1918 the Jerome Verde Co. continued exploration work and opened up a possible extension of the United Verde Extension orebody on the Maintop claim. Stoping began above the 900-ft. level in September and continued at the rate of about 60 tons of 8-per cent. ore per day. Development work in 1918 was concentrated on the Main top ore zone, both by crosscuts and drifts and by diamond-drill work.

Humboldt Mayer District.—The Arizona-Binghampton properties at Stoddard were operated continuously in 1918; the output was about 5000 lb. of copper per day. Production for year ended May 31, 1918, was 2,493,003 lb. of copper. Production averaged about 150 tons daily of 3-per cent. ore, which is milled 9 to 1 into 23-per cent. concentrate. The mine is 600 ft. deep, with a series of overlapping ore lenses developed by diamond drilling and systematic underground work. Property consisted of ten claims, to which five more were added by cash purchase of $14,000 in 1918. A new three-compartment shaft 430 ft. from the old shaft was started during the year. The reserves in 1918 consisted of

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100,000 tons of 3-per cent. ore and 150,000 tons of low grade. Production to December, 1919, totaled 90,000 tons of 3-per cent. ore, yielding 5,000,000 lb. of copper. The Hazel and Gold Hill claims were added to the property early in 1919.

The Consolidated Arizona Co. at Humboldt has enlarged its operations by taking over the Black Warrior and Silver Prince mines of the Swastika Development Co. These two bonanza silver mines of the early 70's are only about 300 ft. deep and the deeper ore is complex, carrying copper and lead with manganese as well as silver. The mines are about half a mile from the railroad near the company's De Soto mine.

The Kay mine, 48 miles northwest of Phoenix, has developed ore in schist that varies from 5 to 30 ft. wide and from 5 to 9 per cent. copper. The mine is 600 ft. deep and is reported to show on the bottom level an ore shoot 110 ft. long and 40 ft. wide.

Ray District.—The Ray Consolidated operated continuously during 1918, but scarcity of men made it impossible to operate at full capacity. The mines produced 3,476,749 tons of 1.2-per cent. ore compared with 3,621,233 tons of similar grade in 1917. Production was 83,599,160 lb. of copper, compared with 88,582,649 lb. in 1917.

The ore reserves are reported to be 86,383,642 tons of 2.061 per cent. copper, but developments on the third level from No. 2 shaft indicate a large undeveloped tonnage which will have to be proven by diamond drilling. The cost of a pound of copper in 1918 was 17.193 cts., compared with 12.649 cts. in 1917 and 8.763 cts. in 1914.

The Ray Hercules company finished the greater part of its construction work in 1918, and was ready for operation on a preliminary scale at its new mill.

Superior District.—The Magma company continued in normal operation throughout the year, the Grand Pacific being the only other producer of copper ore, though more or less development work was in progress at the Silver King, Fortuna, Magma Chief, and Queen Creek properties.

The Magma Copper Co. started work on a new shaft, now about 800 ft. deep, which will increase the mine's producing capacity. Development work totaled 11,122 ft. That on the eastern part of the property on the deeper level disclosed a new orebody, while diamond-drill work has proven the main ore deposit to a depth of 2500 ft. The company has a concentrating mill, but much of the ore mined is a high-grade direct-smelting ore consisting largely of bornite.

During 1918, the net cost of copper was 16.425 cts. per pound. The mine produced 90,321 tons of ore yielding 10,968,556 lb. of copper, 463,503

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oz. of silver and 5699.4 oz. of gold. The mill treated 74,441 tons of ore carrying 4.496 per cent. copper, 3.803 oz. of silver and 10 cts. gold. The recovery was 95.33 per cent. of the copper, making a concentrate of 10.78 per cent. copper, 9.41 oz. of silver and 27 cts. gold per ton. Reserves are estimated to be 235,000 tons, carrying 5.7 per cent. copper, 4.2 oz. silver and 0.02 oz. gold per ton, together with 20,000 tons of reasonably assured zinc-lead ore averaging zinc 13.5 per cent., lead 2 per cent., and silver 12 oz. per ton.

In July, the Fortuna mine, 5 miles north of Superior, by diamond-drilling from the face of a 1050-ft. drift tunnel on a small vein, cut into 22 ft. of gray copper ore carrying silver, lead and copper with a value of $45 a ton. This was subsequently opened by an extension of the tunnel and at a depth of 400 ft. beneath the outcrop. The property is an old silver mine worked from 1875 until 1896 by a 430-ft. shaft and a 620-ft. tunnel.

At the Grand Pacific property development work was concentrated on the sinking of a new incline shaft from the lower tunnel at a point about 1800 ft. in from the portal and beneath the stoped ground, from which shipments were made during the year. A fire destroying the compressor house, new machinery was installed. The shaft was 300 ft. deep at the end of 1918, but had not yet cut ore. The mine workings are on a cross vein, similar to that of the Magma mine save only that no porphyry dike occurs, or at least is not positively recognizable.

The occurrence of shoots of high-grade shipping ore in the two upper tunnels in the hanging wall limestone, and extending downward to within 100 ft. or so of the lower tunnel, is believed to warrant sinking a shaft to water-level and thoroughly prospecting for not only the downward extension of the known ore shoots, but the "bedded" L. S. & A. vein as well.

Yuma County.—The Silver Bell Mine, owned by the American Smelting & Refining Co., was formerly held by the Imperial Copper Co. The ore averages about 3 per cent. and the mine yields about 10,000 tons yearly. The old company had a very complete plant including mill, residences, railroad and, at Sasco, a small but model smelting plant.

The Swansea Consolidated Gold and Copper Mining Co., whcse old Swansea mine, better known as the Clara mine, is operated on a 50-per cent. profit-sharing basis by Chas. W. Clark and J. Ross Clark under the name of the Swansea Lease, Inc., was operated during the year. The mine contains a desirable fluxing ore consisting of hematite with chalcopyrite, formed as an irregular lens in precambrian limestone, part of a schist complex; the ore appears to lie alongside of or with an andesite dike.

California.—The copper mines of the State produced 47,331,769 lb. of copper in 1918, valued at $11,690,957, compared with 48,153,139 lb. in 1917, valued at $13,145,807.

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The Shasta district continues to be the largest producer, but there are also active mines in Plumas, Calaveras and Siskiyou counties.

Near the year's end, arrangements were made for the reopening of the Ord Copper Mines near Dagget, San Bernardino County, where contact veins occur between different igneous rocks. The gangue carries barite, which has prevented concentration by ordinary methods. The ore zones vary up to 50 ft. across and are traceable for 3 miles. Existing workings show ore bands 5 to 6 ft. wide reported to sample 4 per cent. copper and $4 gold and silver per ton.

The Anaconda Copper Co. through its subsidiary, the International Smelting Co., exercised its option on control of the Walker Mining Co. property in Plumas County; the property is reported to have 900,000 tons of $25 ore proven. The Mountain Copper Co., Ltd., had an output, Jan. 1, 1919, of 650 tons daily from the mines at Iron Mountain and 500 tons daily from the Hornet. Production for 1918 totaled 6,802,612 lb. of copper, compared with 8,122,325 lb. in 1917.

Idaho.—This State produced 6,533,888 lb. of copper in 1918 valued at $1,613,870, compared with 7,827,574 lb. in 1917. The largest single producer was the Empire Copper Co. at Mackay; the Basin mine nearby also operated. The National mine in the Coeur d'Alene district near Murray resumed operations, mining and milling quartz peppered with copper glance and chalcopyrite, and averaging around 2 per cent. copper. The Richmond mine also in this section shipped crude ore. Two mines near Salmon were also shippers of small amounts of ore.

Michigan.—The copper mines of this State yielded 231,096,158 lb. of copper, compared with 268,508,091 lb. in 1917. Steadily rising costs of supplies, a marked labor shortage and the abrupt cessation of demand when the armistice was declared, were the factors which led to the closing down in 1918 of a dozen properties of the Copper Range which had not yet reached the productive stage. At the end of the year there were actually eighteen producing companies and two active prospects, namely Seneca and Old Colony-Mayflower.

Several of the high-cost producers will find it wise to shut down, but as a whole the district can keep up production despite the low grade of the rock. Of the eighteen mining companies active in 1918, the Franklin output had the lowest average grade, the recovery being but 0.5 per cent. or 10 lb. per ton. The Osceola Consolidated came next with 14 lb. per ton and the Centennial with 16 lb. per ton. Five companies mined 17-lb. rock, while the great Calumet & Hecla Co.'s mines averaged but 20 lb. or 1 per cent. copper. The Champion ore was the highest in grade, the recovery being 36 lb. per ton, 2 lb. more than the Baltic.

The Calumet & Hecla properties produced 67,968,357 lb. in 1918,

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compared with 77,495,283 lb. in 1917. By increased efficiency and the retreatment of its old tailings, recovered from the lake into which they were run in former years, the cost per pound has been kept down despite the great depth of its mines and the lessened copper content in the Calumet conglomerate at depth.

Quincy, the oldest mining company of the Michigan Copper district, organized in 1848, and a dividend payer since 1862, put in a new hoisting plant in 1918 good for 14,000 ft., increased its mill capacity, and has proven that the Pewabic lode carries as good values at great depth as it does a thousand feet down. Its output runs about 100,000 tons a month of 17-lb. rock.

The Lake Copper Co., whose fiscal year ends April 30, mined 63,191 tons of ore yielding 1,461,893 lb. of copper as 2,246,145 lb. of concentrate averaging 65.07 per cent. copper.

COPPER PRODUCTION IN MICHIGAN
(Pounds of fine copper)

Mines.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Adventure..	*Nil*	*Nil*	8,727,312	.....	.....	.....	*Nil*	*Nil*	*Nil*
Ahmeek....	11,844,954	15,196,127	16,455,769	9,220,874	13,643,605	21,800,492	24,142,158	27,919,812	24,851,235
Allhouez...	4,655,702	4,780,494	5,525,455	4,091,129	6,056,548	10,043,459	10,219,200	8,892,915	7,071,218
Atlantic....	19,018	*Nil*	*Nil*	44,370	.....	.....	(*b*)	(*b*)	(*b*)
Baltic.....	17,549,762	15,370,449	13,373,961	7,736,124	7,001,945	12,028,947	(*b*)	(*b*)	(*b*)
Cal. & Hecla.	72,672,469	72,861,925	67,856,429	45,016,890	53,691,562	72,613,320	76,762,240	77,495,283	67,968,357
Centennial..	1,572,566	1,493,834	1,742,338	1,612,262	2,287,532	2,347,509	2,367,400	2,002,857	2,492,857
Champion..	19,224,124	15,639,426	17,225,508	12,080,592	15,807,206	33,407,599	54,747,498	31,268,130	.....
Franklin ...	966,353	820,203	1,710,651	1,021,440	93,283	1,314,969	3,116,566	.....	.....
Isle Royale.	7,567,399	7,490,120	8,186,957	4,158,584	6,593,451	9,342,106	12,412,111	13,480,921	15,442,508
Mass.....	1,321,885	1,326,898	2,045,006	1,213,545	2,944,952	4,638,452	4,752,538	4,000,000	.....
Michigan...	36,682	327,773	300,000	.....	.....	.....	.....	.....	.....
Mohawk....	11,412,066	12,091,056	11,995,598	5,778,235	11,094,859	15,882,914	13,834,034	12,313,887	.....
Osceola.....	19,346,566	18,388,193	18,413,387	11,325,010	14,970,737	19,731,472	19,586,501	16,084 958	15,919,647
La Salle....	.....	.....	.....	287,200	540,731	*a* 700,000	1,380,352	1,919,775	.....
Quincy.....	22,517,014	22,252,943	20,634,800	12,184,128	15,356,380	22,045,813	21,065,612	22,195.577	19 948,965
Superior....	3,181,041	3,236,233	3,921,974	2,992,765	3,217,635	4,000,000	3,034,656	2,201,672	1,676,446
Tamarack..	11,063,606	7,494,077	7,908,746	4,168,743	1,074 808	3,888,150	6,606,620	.....	.....
Trimountain	5,694,868	6,120,417	6,980,713	4,990,938	5,048,306	8,302,896	(*b*)	(*b*)	(*b*)
White Pine.	.....	.....	.....	.....	.....	.....	4,207,449	4,067,529	3,273,680
Winona....	*Nil*	*Nil*	2,307,237	1,448,737	1,352,084	1,732,638	2,167,255	.....	.....
Wolverine..	10,469,253	9,630,639	9,408,960	1,550,000	3,435,459	*a*) 7,400,000	.....	.....	.....
Victoria....	1,164,564	1,303,331	1,224,911	4,488,000	1,486,242	1,499,695	1,661,832	.....	.....
Others.....	899,647	294,873	.....	.....	.....	.....	.....	.....	.....
Totals ...	223,179,539	216,119,011	225,945,712	135,409,566	165,697,325	253,710,422	273,692,525	268,508,091	231,036,158

(*a*) Estimated as given in *Min. Sci. Press*, Jan. 8, 1916, p. 63.
(*b*) Included in Champion (Copper Range Co.).

DIVIDENDS PAID BY MICHIGAN MINES

Mine.	1916.	1917.	1918.	Mine.	1916.	1917.	1918.
Calumet & Hecla...	$7,500,000	$7,500,000	$5,500,000	Ahmeek...	$2,500,000	$2,400,000	$1,600,000
Copper Range Con.	3,941,648	3,943,913	.....	Allouez ...	700,000	900,000	600,000
Mohawk.....	1,700,000	2,050,000	.....	Champion.	6,460,000	6,014,541	.....
Osceola.....	1,826,850	1,346,100	961,500	Isle Royale	450,000	750,000	375,000
Quincy.....	1,760,000	1,980,000	$935,000	Centennial		180,000	180,000

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Montana.—The great mines of Butte continue to make it the world's greatest copper district, and the Anaconda Copper Co. continues to be the world's greatest copper producer.

The State's output for 1918 was 323,174,850 lb., an increase of nearly 50,000,000 lb. over the 274,462,574 lb. produced in 1917, when the mines were tied up or operations curtailed by strike trouble.

The Anaconda company is a great industrial concern and while copper is still its greatest product, its production of lumber, cement, brick, arsenic and other products is increasing each year, and the newest industry, the manufacture of phosphatic salts from phosphate rock, may in time become itself a very great industry. The company owns coal mines, oil wells and heavy interests in the Inspiration and Greene-Cananea Copper companies as well as the International Smelting Co., International Lead Refining Co., Raritan Copper Works and United Metals Selling Co.

During 1918, the mines of the company produced 4,918,468 tons of ore and 6553 tons of precipitates, a total of 4,925,021 tons. In 1918, a total of 41.85 miles of development was done in the form of drifts, crosscuts, raises, shafts, and winzes, as compared with 38.61 miles during 1917. Shafts were sunk additional depths aggregating 4991 ft. The results of development work were satisfactory.

The copper reduction works treated during the year 4,959,580 tons of ore and other cupriferous material in Anaconda, and 57,000 tons of ore and other cupriferous material at Great Falls. Of this amount 4,350,446 tons of ore was produced by company mines, 618,256 tons of ore was either purchased from or treated for other companies, and 47,878 tons of precipitates and cleanings from the old works at Anaconda and Butte was treated. At Anaconda, 279,030,318 lb. of copper, 10,001,605 oz. of silver, and 59,403 oz. of gold were produced. At Great Falls, 14,573,408 lb. of copper, 966,300 oz. of silver and 4914 oz. of gold were produced.

The electrolytic copper refinery at Great Falls produced during the year 191,404,125 lb. of cathodes, 189,067,167 lb. of which was melted into shapes at Great Falls. The copper-leaching plant at Anaconda treated during the year 500,688 tons of tailing and 64,978 tons of copper ore, from which there was produced 6662 tons of cement copper.

The 1918 average monthly copper production of the Anaconda smelters at Anaconda and Great Falls was about 24,500,000 lb. monthly. This included the output of the Tuolumne and North Butte companies, also operating at Butte, but not that of the East Butte company's smelter, whose production was around 2,000,000 lb. monthly. The

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Davis-Daly, Butte Duluth, Elm Orlu and Bullwhacker mines were also copper producers in 1918.

The Davis-Daly's Colorado mine yielded 52,996 tons in the year ending June 30, 1918, from which 5,894,396 lb. of copper was recovered, with 260,672 oz. of silver. An initial dividend of 50 cts. was paid by this company in 1918.

Nevada.—This State has several producing copper districts, of which Ely, Yerington, and Copper Basin (Battle Mountain) were active in 1918. The first named so far surpasses the others as to make it the one great copper camp of the State. The combined 1918 copper output of the State was 116,316,441 lb., compared with 122,794,704 lb. in 1917. The Ely mine produced nearly 84 per cent. of the total, with the Blue Stone, Nevada Douglas and a few small producers at Yerington, supplying the Mason Valley smelter, whose output was about 1,300,000 lb. monthly.

The Wall St. and the Calavada mines near Luning were also producers.

A remarkable fact concerning the Nevada Consolidated property is that despite the very large amount of ore mined yearly by its steam-shovel operations the development work by churn drilling has steadily increased the measurable ore reserves each year. In 1905, they were 5,300,000 tons of 2.08-per cent. ore. By 1918 they increased to 70,025,322 tons and this despite an annual depletion that has averaged 3,422,068 tons of ore treated annually since 1914 and which reached 4,064,095 tons in 1917.

A few of the mines of the Consolidated Coppermines Co. were worked in 1918. Some of this year's output came from the company's Ora claim mined by the Nevada Consolidated as part of the big Liberty steam-shovel pit. At the Alpha shaft stoping work on the 1200-ft. level has yielded over 2500 tons of 7.9-per cent. ore and new drifts west and north on this level opened 10-per cent. ore. The greater part of the year's output came, however, from the Bunker Hill and Morris claims.

The Yerington or Mason Valley district in western Nevada is, next to Ely, the most productive copper district in the State. Before 1912, it had not produced much copper, but from 1912 to the end of 1918 it produced 80,000,000 lb.

Mining began in the district as early as 1865 at the Ludwig mine. Before 1907, however, mining was intermittent and the output was small. The most important early operation was the mining of natural bluestone, which occurred in the outcrops of the orebodies of the district. Many thousand tons were mined to furnish the copper sulphate used at Virginia City in the Washoe process milling the silver ore of the

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Comstock lode. The early attempts were directed chiefly to mining the oxidized ores, which were naturally richer though far less abundant than the sulphide ore. In the absence of transportation facilities the larger bodies of primary ore, nearly all of which are of low grade, were not commercially attractive.

The district revived about 1907. Some of the largest deposits were bought by companies having adequate capital, and active exploration and development were begun. The Nevada Copper Belt Railroad, begun in August, 1909, and completed to Ludwig in September, 1911, was built into the district from Wabuska, on the Southern Pacific system. A smelting plant, eventually increased to a capacity of 1800 tons a day, was constructed by the Mason Valley Mines Co. at Thompson, 2 miles north of Wabuska. It began operations on Jan. 6, 1912, and soon made a considerable output, largely from the ores of the Yerington district.

The copper deposits of the district consist of chalcopyrite and pyrite intergrown with pyroxene, garnet, and epidote. They are of the contact-metamorphic type.

Mining operations in the Yerington Nevada copper district were somewhat curtailed in 1918, the local smelting plant which handles most of the ore produced in the district closing down one furnace Apr. 27, 1918, the other operating until nearly a year later. The main ore supply came from the Bluestone Mining & Smelting Co. and the Nevada-Douglas mines. Of a total of 336,933 tons smelted, only 118,251 tons came from the Mason Valley group.

The Copper Canyon Mining Co. continued shipments from its Copper Canyon mine at Copper Basin, southwest of Battle Mountain. The company has also purchased the Copper Basin property located about 10 miles from the Copper Canyon mine. Extensive development work has given very good results.

New Mexico.—The Chino Copper Co. continues to be the State's greatest copper producer, with the Burro Mountain plant of the Phelps-Dodge Corp. the next largest. The 1918 production totaled 79,501,333 lb. compared with 83,339,782 lb. in 1917. The Eighty-five mine, the Apache mine at Hachita, Orogrande, Otero County, and the Carocito mines near Scholle, were also producers.

The Burro Mountain mines have 3,600,000 tons of 2.30-per cent. copper ore actually developed and are adding to this yearly. The mine produced 13,139,053 lb. of copper in 1917 from ore averaging 1.97 per cent. copper, the recovery being 72.26 per cent. In 1918 production amounted to 17,293,266 lb. of copper from 1.928-per cent. ore; costs of mining decreased and those of concentrating increased slightly.

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Chino Copper produced 79,340,372 lb. of copper at a cost of 17.178 cts. per lb., compared with the 1917 production of 83,339,781 lb. at 11.39 cts. per lb. Reserves on Dec. 31, 1918, were 95,580,737 tons of 1.63 per cent. copper. In 1918 the mill treated an average of 10,510 tons per day of 1.63 per cent. copper with a recovery of 63.275 per cent. Milling costs, $1.37 per ton, were 33 per cent. higher than in 1917. Two sections were added to the mill, making a total of seven.

Porto Rico.—The copper deposits found in the center of the island occur in a zone of brecciation running N. 20° E., with a second belt that runs northwest and southeast and dips 40° to the southwest. The ore appears to be a typical volcanic breccia whose fragments are cemented by chalcocite and cuprite. Samples cut 2 ft. deep averaged 3 per cent. copper and a 200-ton shipment to New York (Vogelstein) gave a 5-per cent. smelter return. The ore occurs at an altitude of 1050 ft. in the foothill porphyry of a diorite mountain. It is accessible by railway to Manite, the graded Government road to Morovis, and trail to property. The work shows a zone 15 ft. wide and exposed for 100 ft. long with various open cuts and tunnels.

South Dakota produced only a small amount of copper ore in 1918, from which 90,000 lb. of copper are reported to have been recovered.

Texas had a small copper production in 1918, from the Red Bed ores of Foard and Knox counties.

Utah.—This State did not quite maintain its production of 1917, the 1918 mine output being 227,169,630 lb., compared with 246,674,153 lb. the year previous.

Bingham Canyon continued to furnish the largest tonnage of ore of any mining district not only of America but of the world, the Utah Copper Co. handling over 20,000 tons of ore a day and producing 16,500,000 lb. of copper monthly. The Utah Consolidated was the next largest copper producer, with the Ohio Copper Co. third. The other producers of the State include the Tintic Standard and Iron Blossom near Tintic, Ophir Hill at Ophir, Columbus Rexall at Alta, Salt Lake Copper Co. near the State boundary not far from Tecoma, Nevada, and the Utah Leasing Co., treating the dumps and tailings at Newhouse.

The Utah Copper Co. is still the premier of the so-called "Porphyry Coppers" and has established a world record for quantity of ore mined and treated and for cheapness of production. The cost of making a pound of copper varied for many years from 7.08 cts. to 8.54 cts. In 1918 costs increased to 16.81 cts. for the third quarter and 17.88 for the last quarter of the year, but without allowance for gold and silver in the ore of 1.35 cts. per lb. of copper produced. With this deduction the average cost per lb. for the year 1918 was but 14.533 cts. as compared

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with 7.245 for 1914. The higher figure, however, includes war taxes, depreciation and an increase of stripping cost of 5 cts. per ton milled. With only the same items used in figuring 1914 costs, the 1918 figure would be 10.5 cts. per lb. of which amount 0.392 cts. is net mine-mill cost, equivalent to 61.7 cts. per ton of ore treated and 6.58 cts. is the cost of smelting, refining and marketing, compared with 4.93 cts. for the same item in 1914–15. The following table gives the comparative net costs of producing a pound of copper for various years compared with today's figures, with war tax and depreciation charges omitted in order to make a fair comparison.

	1918, Cts.	1917, Cts.	1914–15, Cts.	1912–13, Cts.
Mining, ore freight, milling, and in 1918 and 1917 taxes and depreciation, and obsolescence in 1918	9.08	6.85	3.09	4.11
Stripping and development	0.68	0.50	0.45	0.61
Total crude-ore cost or mine-mill cost per pound net copper recovered	9.76	7.35	3.54	4.72
Less railway dividends, gold and silver by-product, rents and miscellaneous Utah income	1.80	1.71	1.39	1.46
Less taxes, depreciation, and in 1918 obsolescence and new stripping charge increment	4.04	2.79	.....	.....
Net mine-mill cost	3.92	2.85	2.15	3.26
(Per ton of ore)	(61.7)	(46.5)	(37.7)	(52.3)
Smelting, refining, marketing	6.58	5.35	4.93	5.28
Net costs per pound copper before war tax and depreciation	10.50	8.20	7.08	8.54

During the year 1918 the Utah Copper Co. produced 197,978,557 lb., compared with 206,174,442 lb. in 1917. This total includes 1,378,392 lb. from sulphide ore shipments, 2,396,995 lb. recovered by the leaching plant, and 35,481 lb. from mine precipitation work.

In the last quarter of the year 1918 the monthly production averaged 16,101,231 lb., derived from an average monthly production of 1,015,000 tons of ore averaging 1.23 per cent. copper, treated with an average extraction of 64.43 per cent., or a recovery of 15,463 lb. of metal per ton. The magnitude of the company's operations is indicated by the fact that 4,064,091 cu. yd. of capping were removed during 1918, and that the total net income was $18,945,780, and dividends disbursements $16,244,-900, or $10 per share.

The following table shows what the company did with the enormous profit—16 cts. a lb. net on 196,000,000 lb. in 1917 and 11¾ cts. on 188,000,000 lb. in 1918.

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	1918.	1917.
(a) Gross profit:		
Company reports	$18,945,780	$23,910,777
Actual operating profit	26,556,721	29,369,281
Disposition of profit:		
(b) Tax reserve	$5,972,721	$4,750,291
(c) New plant and properties	4,637,840	5,302,578
(d) Excess stripping	966,484	680,611
(e) Liberty Bonds, net	7,088,206	2,387,408
(f) United War Charities	500,000	.....
(g) Red Cross dividend	.....	812,245
(h) Dividends	16,244,900	22,742,860
(i) Added to working funds:		
To cash available	.....	2,089,823
To copper inventory	.....	.....
To supplies, etc	.....	2,928,257
Total funds disposed	$35,410,151	$41,694,073
(j) Drew from working funds:		
From cash	$3,029,657	.....
From copper inventory	4,457,204	$2,671,984
Depleted supplies	582,755	.....

Notes: (a) Gross income includes reported profits on copper, dividends on Bingham & Garfield Ry. and on Nevada Consolidated Copper Co. stock; rents, interest, gold-silver and miscellaneous income, after charging operating costs and 7½ cts. per ton milled as a fixed charge to repay stripping expense, but before depreciation, war tax, obsolescence and depletion. The company reports profits after deducting war taxes and depreciation in both 1918 and 1917, and after also deducting obsolescence in 1918. (b) Taxes quoted include some state taxes and insurance reserve.

The Ohio Copper Co. completed three out of five 600-ton sections of its new mill at Lark. The three sections were put in operation and the old equipment removed to make room for the more compact and efficient flotation plant. A disastrous fire occurring in August burned the north end of the mill and bins. The new treatment has effected a marked increase in recovery, working in ore consisting of quartzite peppered with tiny particles of sulphides, pyrite, chalcopyrites and copper glance. The profitable treatment of such ore averaging but 0.8 per cent. copper or 16 lb. per ton and mined under high-cost conditions is an achievement of which Mr. Colvocoresses, the consulting engineer, may well feel proud.

Six miles from Gold Hill, Utah, the Copper Queen, Midland Mining Co., is prospecting several bedded veins on limestone contact. A low-grade cupriferous pyrite has been found in several places.

The Cardiff and Big Cottonwood Coalition mines in Big Cottonwood Canyon, near Salt Lake City, were actively prospected in 1918. The Cardiff was a shipper, the Cottonwood sending out merely 50 tons of $11.57 ore mined in development.

Washington.—The State has copper deposits near Chewelah, north of Spokane and in the Cascade Range. The output for 1918 was 1,922,406 lb. compared with 2,199,518 lb. in 1917, largely from the United Copper mines, whose output of concentrate and crude ore was about 500 tons monthly. Other producers were the Loon Lake, also north of Spokane; Reardon Copper Co., near Turk; Tago, a new mine west of Springdale and Lone Star and Washington near Danville, Ferry County; the Copper World Extension, Okonagon County, and the Sunset mine near Index.

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Copper Mining in Foreign Countries

Africa.—The copper industry of Africa was naturally quite seriously crippled by the great war. The Bwana M'Kubwa Copper Co. operating in northern Rhodesia was obliged to suspend operations in March, owing to lack of ocean carriage for the product. The mine had 45,000 tons of high-grade tailings available for retreatment and the mill yielded 1419 tons of concentrate, only half of which could be shipped.

In the Belgian Congo or Katanga region copper mining is practically confined to L'Union Minière du Haut Katanga. Only the richer ores of the Star of the Congo and the Kambore mines were treated in 1918 and the copper output for 1918 is only about 20,000 tons. The smelter near Elizabethville contains five blast furnaces, which, with two erected in 1918, will give a total capacity of 100 tons of copper metal per day. The 1918 output is estimated at 40,000 tons. The company has proven immense quantities of oxidized but low-grade ore which can be treated by leaching and electrical deposition.

The program of expansion already planned provides for an expenditure of £3,000,000 to provide a plant ready by 1921 to produce 50,000 tons of metallic copper yearly. The company employs 450 white men and 7000 natives. With the completion of the Benguela railway (which now runs from Angola 325 miles eastward) to the east coast, the overland route will be materially shortened and the ocean route to London reduced fully 3000 miles.

Australia.—The copper mining industry of Australia is declining despite the strenuous efforts of both Government and operators to stem the tide. During 1918 the total output was about 72,800,000 lb. (32,500 tons), over half of it coming from Queensland, about 2,240,000 lb. from West Australia and Papua, and about 10,000,000 lb. from New South Wales, South Australia, and Tasmania. During the year copper producers were between the two fires of high cost and low efficiency. The Government's making but 3-month contracts at £108 per ton rendered financing difficult and for small producers impossible. Costs were high as elsewhere throughout the world, that of Mt. Morgan being about £85 per ton of refined copper and Mt. Lyell's £50 per ton; since its ore is low grade, it utilizes the sulphur in fertilizer-making and has very cheap electric power, pyritic smelting, and its own coke works. The Wallaroo, having a labor agreement, had no strikes, and its flotation and leaching and refining plants gave excellent results. The Cloncurry field makes the cheapest copper, as its ores are relatively high grade. Seventy-five per cent. of the country's output came from seven mining companies, viz., Mt. Lyell, Wallaroo, C. S. A., Hampden, Mt. Elliott, Great Cobar, and Mt.

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Morgan, named in the order of their costs. The country has no great deposits of low-grade ore similar to our "Porphyry Coppers" and the only hope of the industry is in cheaper power and better methods of extraction.

Queensland produced 189,979 tons of copper ore valued at £2,087,751, a decrease of 83 tons and £120,481 compared with 1917. The most important district is the Cloncurry, which yields more than half the copper produced in the State. The Mt. Elliott company, which operates the Hampden, South Consols., Great Australia and other mines, started its smelting plant Jan. 16, and closed down Nov. 30, treating 77,482 tons of ore yielding 3580 tons or 8,019,260 lb. of copper. The Hampden Cloncurry copper mines furnished 75,301 tons of ore, which treated in the company smelter yielded 13,249,600 lb. (5915 tons) of copper; 11,436 tons of custom ore was also smelted. The Duchess mine, which normally furnished 85 tons daily, being closed by labor trouble, the main ore supply came from the Trekelano, where a lens of good ore 7 ft. thick and 180 ft. long was opened on the 400-ft. level. The eight lesser mines of the company yielded 8- to 9-per cent. ore.

The Mt. Morgan mine yielded 115,715 tons of ore from which 14,869,120 lb. of copper was recovered. The Mt. Morgan plant started smelting concentrate and handled the material in one furnace, the product of which was converted. A small leaching plant was installed, handling a ton a day, making copper sulphate with subsequent leaching and electrolysis, followed by chlorination of the residue for gold values. The concentrator handled 214,989 tons of ore in the year ending June 2, 1918, and produced 83,567 tons of concentrate. The total output was 17,066,560 lb. of refined copper and 86,219 oz. of gold.

Ore reserves on June 2, 1918, are given as 3,825,685 tons of 2.58 per cent. copper and 6.16 dwt. gold, a decrease of 116,344 tons compared with 1917.

In New South Wales the output declined but slightly. The most important yields furnished during the year were as follows: Great Cobar, 2415 tons; C.S.A. Mines, 2232 tons; Mount Royal Mines, 182 tons; Mount Hope, Ltd., 299 tons; and Abercrombie Mines-Burraga, 300 tons.

The Great Cobar mine was unable to sell its output after Oct. 1, 1918, and together with high costs and poor underground conditions faced the disaster which came early in 1919. The story is a "sad warning to the British Public against mixing promotion with engineering."

In South Australia, the Wallaroo & Moonta Co. had an output for 1918 of 20,809,600 lb. or 9290 tons of refined copper, produced at a cost of £92 15s. 11d. f.o.b. steamer, compared with the Australian Govern-

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ment's price of £106 per ton. This output includes 1454 tons of electrolytic and 2266 tons of Mt. Cuthbert blister copper.

The total ore produced from the Wallaroo mines was 54,501 tons, containing 8.91 per cent. copper. The Moonta mines produced 8782 tons, containing 14.73 per cent. copper. The cementation plant at the Moonta mines produced 790 tons of precipitate, containing 555 tons of copper. The Wallaroo smelting works treated during the past year 68,199 tons of ore, precipitate, and blister. The following metals were produced: 9390 tons of refined copper, 1454 tons of electrolytic copper, 2292 oz. of fine gold, and 1608 oz. of silver, 996 fine. The production of sulphuric acid was 6745 tons.

Tasmania's largest mine is the Mt. Lyell, whose output is nearly 90 per cent. of the State's 1918 production of 5559 tons of blister copper.

Argentina exported copper ingots to the value of $267,118 in 1918, and one of its copper mines in the Famatina district is said to employ over 1000 men. The mines are owned in England and transportation is provided by a 27-mile rope tramway built under government subsidy.

Bolivia.—Though the country has many copper prospects, the only mines being operated are those of Coro Coro. The 1918 output is not definitely known,

PRODUCTION OF COPPER IN AUSTRALASIA
(In tons of 2240 lb.)

Year.	New South Wales.				Queensland.		South Australia.		Tasmania.				Western Australia.			Combined Value.
	Ingots, Matte and Regulus.		Ore.		Copper, Tons.	Value.	Copper, Tons.	Value.	Blister Copper.		Copper Ore.		Copper Ore, Tons.	Copper, Tons. (a)		
	Tons.	Value.	Tons.	Value.					Tons.	Value.	Tons.	Value.				
1909	6,857	£423,642	109	£1,095	14,494	£853,196	5,697	£334,584	8,638	£586,419	1,588	£21,619	6,959	833		£104,644
1910	8,435	450,491	4,455	35,766	16,387	932,489	5,102	306,120	8,193	553,822	671	13,150	6,309	1,261		95,928
1911	10,618	578,198	1,482	11,904	20,384	1,151,351	5,922	332,500	6,022	385,797	2,286	22,852	9,825	829		78,364
1912	8,990	560,025	2,044	19,766	23,120	1,698,280	6,295	461,500	5,136	430,965	1,392	9,479	13,607	1,703		120,158
1913	9,153	595,826	308	2,907	23,655	1,660,178	7,161	488,986	4,569	384,332	1,967	10,922	4,339	82		145,513
1914	3,500	274,671	3	11	18,436	1,118,648	6,881	417,487	7,500	477,361	3,288	18,680	8,913	133		38,174
1915	6,973	.....	*Nil*	*Nil*	19,704	1,428,793	7,725	561,247	7,901	709,167	66	387	737	946		91,169
1916	6,171	.....	*Nil*	*Nil*	19,520	2,265,422	7,279	822,527	6,305	884,689	97	1,765	650	457		64,833
1917	6,576	714,154	*Nil*	*Nil*	19,062	2,208,232	7,213	902,495	5,845	811,583	771	6,171	966	536		85,738
1918	6,510	696,580	*Nil*	*Nil*	18,980	2,087,751	7,169	828,556	5,559	772,162	444	3,944	.....	.....		.....

(a) Ingots and matte.

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but was less than 1917 owing to high shipping rates, scarcity of ships and reduced price of the metal. The ore occurs in steeply tilted beds of sandstone and in cross fissure carrying complex sulphides. This ore is concentrated and the concentrate shipped abroad.

Bulgaria.—The Government is reported to be considering taking over the Bor Copper Mines of Servia, expropriated by the Germans during the war. The mines and plant are reported to be in good condition and the pumps at work. The French company owning the mines resumed control in the latter part of 1918.

Chile.—The gigantic operations of the Chile Copper Co. at Chuquicamata, on which over $50,000,000 has already been spent, together with those of the Anaconda Copper Co. and the Braden Copper Co., will soon make this country second only to the United States as a copper producer.

At Chuquicamata, the reduction plant handled over 3,506,000 tons in 1918, or between 11,000 and 12,000 tons per day, with a copper output of 9,854,000 lb. of copper in October, the best month. The property is the world's largest copper deposit, since the developed ore at the end of 1917 totaled 355,000,000 tons, with an approximately equal amount of probable ore with an average copper content of 2.12 per cent. Moreover, many drill holes are bottomed in ore so that the total amount of ore is yet unknown. Of this enormous amount 233,000,000 tons is oxidized ore, 73,100,000 tons mixed ore and 48,700,000 sulphide ore. The oxidized ore is crushed, leached with a dilute solution of sulphuric acid, and the copper recovered by electrical precipitation.

Construction work was continued throughout 1918 in order to increase the output to 15,000 tons daily or 160,000,000 lb. of copper annually, and in a year or two more to double this amount. Operations in 1917 showed a recovery of 82.54 per cent., treating 10,000 tons daily of 1.76-per cent. ore.

At the Braden property, controlled by the Kennecott Copper Co. owning 99 per cent. of the stock, further development was prosecuted; an underground electric railway 5750 ft. from mine to ore-bin was completed; a 25-ton locomotive will handle 14-car trains of 22-ton cars each; "A" shaft was sunk 690 ft. and numerous improvements made, by which much more work will be done underground to avoid the great snow slides of winter time. The new ore-pass gathering system, and completion of levels and cross cuts on the Teniente side have developed larger tonnages of satisfactory grade. The mill and smelter have been further equipped and the Pangal power project with its 8-mile flume line with 12,350 ft. of tunnel and 10,000 ft. of snow sheds, have been practically completed. Reserves at the end of 1918 were 173,506,300 tons of positive ore of

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2.45 per cent. average copper content, and 90,000,000 tons of probable ore, 1.88 per cent. copper. Treating 6000 tons of 2.29-per cent. ore daily with an average recovery of 76.61 per cent., the company produced 62,500,000 lb. in 1917. In 1918, 5378 tons were treated daily with an average recovery of 78.75 per cent. Output amounted to 38,576 tons of blister copper. Copper sold and delivered totaled 71,362,788 lb. at 26.888 cts. per lb.

Shortly before the end of the year the necessity for curtailing output was apparent, and a gradual decrease was effected, bringing output down to about 50 per cent. of normal. Arrangements have been made with the Kennecott Copper Corporation for the necessary financing in view of the funds needed to carry the large amount of copper on hand and to further the construction program.

Among the many companies held by the German metal octopus, the Galica Mining Co. of Valparaiso, Chile, was one. The output is given as 4200 lb.

The Poderosa Co. was compelled by the embargo on ore shipments to stop production in 1918, which permitted doing much needed development work. Shipments in 1917 amounted to 6980 tons of 31.5-per cent. copper ore carrying 13 oz. of silver.

The Andes Copper Co., belonging to the Anaconda Copper Mining Co., started active construction work on mill, mine equipment, and smelting plant in 1918. This company has 1003 acres of mining land and 4000 acres of non-mineral land. Development work for 1918 shows an addition of 5,500,000 tons of 1.54-per cent. ore to reserves, making a total of 110,934,081 tons of about 1.49-per cent. ore already developed and measurable. This company completed its wharves and warehouses at Barquito, the shipping post; built 58 miles of railway, completed office buildings and employees' houses and built power plant and line.

Lo Aguirre mines of the Santiago Mining Co., whose stock is also owned by the Anaconda, have been under development since 1914, the ore developed totaling over 6,000,000 tons varying from 1.75 per cent. to 3.5 per cent. copper. At the Africana property, which will furnish much needed sulphide ore, copper values varying between 4.5 and 9 per cent. are reported. A total of $15,234,914 had been spent on these Chilean properties up to Sept. 30, 1918.

Canada.—The same factors which controlled the copper mining industry of the United States kept the Canadian mines very active in 1918, until the signing of the armistice in November suddenly stopped all sales of the metal.

The total Canadian production for 1918 was 118,415,829 lb., compared with 109,227,332 lb. in 1917, and greater than the former record produc-

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tion of 117,150,028 lb. in 1916. At the fixed price of 23½ and 26 cts. made in 1918 for the metal by the United States Government, the output did not have so large a money value as that of 1917. In Canadian-produced matte and blister copper there was contained 92,769,167 lb. of copper, and 25,646,662 lb. in ores exported.

In Ontario the 47,047,801 lb. produced in 1918, like the production of 42,867,774 lb. for 1917, was derived almost entirely from the nickel-copper ores of the Sudbury district, with trifling amounts from a few copper properties under development and from the Alexo mine in Temiskaming. As a result of prohibitive mining costs the mines, dependent mainly for their profit on their copper product, were mostly inactive or idle during 1918. The only shipper of copper ore the first half of the year was the Hudson Copper Co. at Havilot. On the other hand, the first 6 months of the year witnessed a most energetic working of the nickel-copper mines of the country, the output of the International Nickel and the Mond Nickel being greatly increased for that period.

In Quebec, whose copper ores are also quite valuable for their sulphur content, the copper content of the ores in which copper was paid for is reported at 5,869,649 lb. in 1918, compared with 5,015,560 lb. in 1917. It came mostly from the Eastern Townships of the province.

In Manitoba much exploration and development work was carried on at the various properties at Schist Lake near the Pas, and an actual production of 6300 tons of copper ore was shipped from the Mandy mine to the Trail, B. C., smelter. At the Flin Flon property diamond drilling until June, 1918, outlined the orebody and proved its tonnage. An 80-mile railway to the Pas with development of hydro-electric power and the erection of mill, smelter and 35-mile power line will be necessary to make the enterprise a productive one. Discoveries of other deposits of copper ores were made in 1918 in the Athapapuskow Copper Lake areas.

British Columbia, as usual, yielded the largest copper output of any of the Canadian provinces, the output for 1918 being 63,400,000 lb. The Granby Consolidated is much the largest producer, its Anyox smelter treating 828,000 tons of ore from the Hidden Creek mines, yielding 30,394,000 lb. of copper, $107,000 in gold and $282,000 in silver. Granby's reserves are 23,531,208 tons of 2.135 per cent. copper. The Phoenix mines of this company and the Canada Copper Corp. are approaching exhaustion, the Granby smelter treating 444,000 short tons of ore returning 6,300,000 lb. of copper.

The annual report of the Granby Consolidated Mining, Smelting & Power Co., Ltd., for the year ended June 30, 1918, states that large coal measures had been acquired on Vancouver Island, and coke ovens

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being constructed at Anyox, B. C., were expected to be in operation by Jan. 1, 1919, to yield 250 to 300 tons per day.

The total amount of ore smelted was 1,468,393 tons from the company's own mines, and 25,722 tons from other sources. The metal produced amounted to 44,685,001 lb. of copper, 550,163 oz. of silver, and 30,730 oz. of gold.

Gross receipts amounted to $11,644,310, which, after the usual deductions, left net profits carried to surplus account of $1,527,133, making a total for this account of $4,929,459, out of which dividends were paid amounting to $1,500,042. Ore reserves, as of June 30, 1918, were estimated as follows:

	Tons.
Ore containing from 3 to 5 per cent. copper	64,740
Ore containing from 2 to 3 per cent. copper	10,480,150
Ore containing from 1 to 2 per cent. copper	3,017,713
Ore containing less than 1 per cent. copper	9,968,605
Total	23,531,208

The Phoenix mines and Grand Forks smelter were indefinitely closed down in September, 1918. At Rossland, the mines were closed down in May.

The Greenwood smelter (formerly British Colonial Copper Co.) treated 165,000 tons of ore in 1918, obtaining 2,200,000 lb. of copper with some gold and silver. This smelter was closed down near the end of the year for want of ore.

At Copper Mountain on the Similkameen River not far from Hedley development work has proven over 12,000,000 tons of 1.74-per cent. copper ore. The milling plant under construction in 1918 is expected to operate July 1, 1919.

On the Pacific Coast the Brittania mine treated 750,000 tons of ore in 1918, recovering 18,250,000 lb. of copper. Extensive development work for the year includes four tunnels run entirely through the mountain, with two others at the 1200- and 1600-ft. levels still being driven. Ore reserves amount to 18,754,502 tons of 1.97-per cent. copper ore.

On Texada Island, the Marble Bay mine continued operations and had shipping tonnage been available, the Moresby Island and Sulzer mines could have had increased outputs.

In the Yukon the Pueblo mine closed down so that the production dropped from 2,460,079 lb. valued at $668,650 in 1917 to 300,000 lb. valued at $73,884 in 1918. Total exports from British Columbia in 1918 amounted to 60,536 tons valued at $20,772,109.

Newfoundland.—During 1918 construction work at the Great Northern mine at Twillingate, near the well-known Tilt Cove mine, was practically completed. The vein, which runs across a narrow peninsula and is opened for half a mile in length and a width of 160 ft., averages 2 per

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cent. copper, but the ore shoots run 4 per cent. copper with 50 per cent. sulphur and $1.50 gold per ton; this richer ore is somewhat bunchy and zinc blende occurs with the copper pyrite. About 9,000,000 tons are estimated, about half this amount being measurable. The mine is worked as an open quarry down to sea-level and several shafts show its continuance downward for the 150 ft. tested.

The mine was operated with handsorting until 1918, when a complete new mill with 150-ton flotation unit was installed. An 800-hp. steam plant and complete equipment of compressors and mine and mill machinery was installed.

Cuba.—The Cuba Copper Leasing Co. operating the El Cobre mine near Santiago, controlled since 1908 by Beer, Sondheimer & Co., an enemy alien firm taken over during the war, shipped its ore and concentrate to the Norfolk, Va., copper smelter, also owned by the same firm. According to the report of the Alien Property custodian, the 1918 product was 21,100 tons of concentrate and 1811 tons of crude ore, compared with 26,957 tons of concentrate in 1917, 22,370 in 1916, 17,552 in 1915 and 19,892 in 1914, besides a tonnage of crude ore running from 2038 in 1917 to 8081 in 1915.

The following table shows the imports of copper ore from Cuba to the United States since 1910, in long tons, for the fiscal years ending June 30:

Year.	Ore.			Concentrates.		
	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton.
1910	36,534	$552,231	$15.12	.....	.....	.....
1911	76,629	795,353	10.38	.....	.....	.....
1912	75,576	727,229	9.62	.....	.....	.....
1913	35,905	676,245	18.84	.....	.....	.....
1914	29,177	1,270,182	43.53	.....	.....	.....
1915	61,080	2,680,268	43.88	.....	.....	.....
1916	69,789	4,846,995	69.46	6,900	$381,236	$55.25
1917	86,824	5,824,698	67.10	8,000	469,168	58.65
1918	78,681	4,041,058	51.36	11,540	896,040	77.65

Germany.—The country was bare of copper in 1918, so far as peace industries were concerned; indeed, there was no general market for the metal, the Government having commandeered all stocks and imports being cut off. It is estimated that the peace needs of the country have heretofore been about 200,000 tons a year. During hostilities, the War Metal Co. rationed out stocks. The Mansfield Copper Co. is reported to be in a bad way, the mining expense from Oct. 1, 1918 to Jan. 20, 1919, being reported as 47,000,000 marks, while sales totaled but 20,000,000 marks, declining from 11,000,000 marks in October to 2,500,000

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in December. Coming as this does after four years of intense activity to supply war's demands, the company, to avoid discharging its 80,000 employees, appealed for state aid, but in vain. Its 1918 production was 15,978 tons of refined copper, against 19,980 tons in 1913.

Hayti.—The Blanton Copper Mining Syndicate, owning copper properties in San Domingo, did no new work in 1918. The output for 1916 was 348 tons and for 1917 was 233 tons of picked ore, treated at the Norfolk, Va., smelter.

The Hayti Mines Co. own an extensive area of copper-bearing territory, 12 to 15 miles from Gonaives, a seaport on the west coast. The ore carries bornite and chalcopyrite in a garnetiferous limestone near a quartz diorite mass at Terre Neuve. Though small shipments of rich ore have been made, the property is still in the development stage.

Japan.—Japan is the second largest copper producer of the world, though its annual output for 1918 was but 95,800 metric tons, compared with 111,256 in 1917 and 101,467 in 1916. The decline in production is largely due to the reduced output of the four big mining companies, Ashio, Besshi, Hitachi and Kosaka, which together produce half the Empire's output. As indicative of the market for the Japanese product the following table of exports is interesting.

COPPER EXPORTS OF JAPAN
(In long tons)

	Europe.	America.	China.	Hong Kong.	India.	Totals.
1908	25,000	5,515	2,220	.....	2,766	35,501
1909	22,170	9,528	1,589	.....	2,088	35,375
1910	21,116	8,846	957	.....	4,218	35,137
1911	17,288	11,009	3,688	.....	2,332	34,307
1912	23,351	6,917	7,317	.....	805	38,390
1913	19,843	5,543	13,320	.....	3,574	42,280
1914	19,642	5,207	13,577	.....	3,274	41,700
1915	45,140	7,800	1,430	.....	1,220	56,000
1916	53,796	2,921	1,577	52	86	58,432
1917	58,624	2,617	4,929	90	3,991	71,051
1918	20,666	37	7,392	911	2,427	31,435

It is believed by those familiar with the situation that Japanese mines greatly reduced their ore reserves in 1916–1917, taking advantage of high prices then prevailing and husbanding output in 1918 owing to reduced price and curtailed shipping space.

Mexico.—The copper produced in Mexico comes mainly from a few big mines, namely those of Cananea and of Nacozari, Sonora, and the Rothschild mines at Boleo, Lower California. A considerable production also comes from the various custom smelters of the country, especially the four owned by the American Smelting & Refining Co., which, because of the unsafe condition of the country, were closed down for two years, but reopened in March, 1918. Much of the ore handled by the Guggenheim

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interests in Mexico contains both lead and copper, lead smelting being a very important part of the Mexican business. Two of the plants produce copper matte, which has to be shipped to Aguascalientes for conversion into blister copper, and this in turn is sent to Perth Amboy, N. J., to be refined.

During 1918 there were eleven smelting plants operating in Mexico and the official Mexican statements of copper produced are at variance with the known facts. The smelter production of Aguascalientes probably does not represent an accurate record of the copper produced by the mines of that State, just as the figure of 31,089,484 lb. given as the 1917 production of Nueva Leon came almost entirely from mines outside that State.

In Lower California, the French Compagnie du Boleo continued operations throughout 1918, though hampered by curtailed shipping facilities. In Coahuila, the Torreon and Saltillo plants, the first named an American Metal Co. plant, the latter owned by the Mazapil Copper Co., operating almost entirely on lead ores, produced relatively small amounts of copper matte. The actual mine production of Coahuila is estimated as 660,000 lb. of copper. At Monterey, Neuva Leon, the American Smelting & Refining Co. smelter treated a small tonnage of copper ore and the Monterey M. S. & R. Co. is said to have had a small output of matte. The Mexican Metallurgical Co. at San Luis Potosi treated copper ore and the American Metal Co. at Villaldama handled a very considerable tonnage of copper-bearing ore.

The strictly copper-producing mines of the country operated on an extensive scale. At Cananea, Sonora, which is only about 50 miles south of Bisbee and visible from there, the mines extend along the north side of an isolated mountain range for about 6 miles. Operations were resumed in 1918 after the long shut-down from June 22 to Dec. 10, 1917, due to a dispute with the Mexican Government over arbitary taxation rulings, the output for the year being about 53,270,000 lb., compared with 27,000,000 in 1917, 62,000,000 in 1916 and 17,000,000 in 1915, against a normal of about 48,000,000 lb.

Though mining operations had been conducted on so large a scale that the great bonanza orebodies of former years are worked out, the properties are reported to have a long lease of life ahead of them and in 1918 mining of new ore bodies yielded 10-per cent. copper ore, as compared with an average for many years past of 2- to 3-per cent. copper ore.

The Democratic Mining Co., operating an independent mine and smelter in the very heart of the Greene Cananea holdings, was operated throughout the year, but closed down in March, 1919. The Carnegie Lead & Zinc Co., which owns the old Calumet Sonora mines two miles

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northwest of Cananea, yields a small copper output and was operated on a small scale in 1918, putting up a new mill and developing the mine. The Hermosillo Copper Co., which has a deposit of copper carbonate ore in limestone, was not operated in 1918, but its property was not molested and work was resumed in 1919.

The Moctezuma Copper Co., operating the Nacozari mines of the Phelps-Dodge Corp., continued operations without interruption during 1918.

Not far from the Phelps-Dodge property, the Nacozari Consolidated has driven a tunnel 3000 ft. long to reach the ore zone at 3500 ft. This work is being done with air drills and has already cut stringers of chalcopyrite ore.

Peru.—The American-owned mines of Cerro de Pasco and those of the Backus & Johnson Co. continued operations throughout 1918, with slightly increased output, and, as heretofore, supplied almost the entire copper output of Peru.

The production of Cerro de Pasco amounted to 71,904,794 lb., compared with 72,645,855 lb. in 1917 and 71,022,788 lb. in 1916; costs are not available. Net earnings, balance after providing for depletion, depreciation, and United States taxes, were $499,916. The ore assays more than 100 oz. of silver per ton; this combined with cheap labor has made the company one of the lowest-cost copper producers. Owing to its long and continuous use and somewhat antiquated type, it has become necessary to remodel the present smelter or erect a new one. With the idea of building a new smelter options have been taken on land near Oroya, the junction point of the Cerro de Pasco Railway Co. and the Central Railway of Peru.

The Backus & Johnson Co., operating as the Sociedad Minera Backus y Johnson del Peru, held a contract with Vogelstein & Co. which the Enemy Alien Property Custodian took over. Production amounted to 24,619,561 lb. of copper, 3,351,300 oz. of silver and 3800 oz. of gold. The company is erecting a 500-ton sampling mill and a 16-oven coke plant.

Russia.—Although very rich in copper deposits, in the Ural and Siberian regions, Russia has thus far been but a small producer of the metal, its mines supplying but half its domestic needs for the last ten years or so.

Owing to prevailing Bolshevik conditions, the Siberian copper mines were shut down throughout the year 1918. No real damage was done. In the Altai region of Siberia, British companies control and dominate the Spassky, Tanalyk, Irtysh and Atbasar copper companies.

In the Ural region, the Kyshtim is the largest company, with 2,500,000 tons of 3-per cent. ore blocked out, and an up-to-date refinery that pro-

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duced 6392 tons of copper in 1916 and about 5000 tons in 1917, but whose operations were seriously curtailed during 1918, no figures being as yet obtainable.

The Caucasus Copper Co., controlling the largest copper deposit of southern Russia, is controlled in America, J. P. Morgan & Co. holding an important interest. Nearly $10,000,000 has been spent on the property since 1900 and the mines are reported to show 3,600,000 tons of 3.1-per cent. copper ore. This company's largest production was 9,000,000 lb. in 1914.[1] At the Spassky Copper Co. no damage was done to any of the company's properties during the period of upheaval there last year. It is expected that when normal conditions return there will be a great commercial development in Siberia, and a large local demand for copper.

By the middle of 1918, the properties of the Kyshtim, Irtysh and Tanalyk corporations were outside the zone of Bolshevist operations and the decrees of confiscation, nationalization, etc., became inoperative, so that operations were resumed on a limited scale. No real damage was done to the Irtysh and Tanalyk properties and operations on a larger scale can be begun when railroad and industrial conditions are more nearly normal. The Spassky mines were also returned to their owners and damages allowed for expropriation.

Spain and Portugal.—The copper output of Spain is reported to have been seriously curtailed by the shortage of shipping in 1918. The total output of the Iberian peninsula is estimated at 41,000 metric tons, of which amount Portugal furnished about one-fifth.

As in former years the Rio Tinto and Tharsis companies furnished the bulk of the output, with the Cordoba Copper Co. a contributor of considerable importance. The Rio Tinto company in 1918 issued 50 million pesetas (about $10,000,000) of 6-per cent. 10-year mortgage debentures, out of an authorized total of an 100,000,000 pesetas.

In Portugal copper deposits occur in an extension of the Rio Tinto field of Spain at Minas de San Domingo, operated by Mason & Barry, and the San Joas de Deserts (Ajustral), operated by Belgian owners.

In addition to San Domingo and Ajustral, chalcopyrite ore is mined at Barrancos and at Serra de Caviera by English interests, small amounts of gold and silver being produced at the latter property as a by-product. Tinoca and Azeiterios, in the northern part of Beira Baixa, and the Vale do Bicho, in the Arouca district, and Zambijeiro near Evora, are the other copper producers in the country.

The San Domingo copper mines are much the largest of Portugal and have been worked since 1858. The ore occurs as lenses of cupriferous pyrite in a mineral zone 2000 ft. long, and 200 ft. wide, lying in Devonian

[1] *Russia*, **3**, 11–13 (1918).

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schist. The ore as mined averages 0.91 per cent. copper and 48.28 per cent. sulphur. The deposit is opened to a depth of 210 meters, and though the copper content has decreased with depth the sulphur makes the ore commercially valuable. The treatment involves leaching out the copper, and shipping the "washed ore" as pyrite.

Shipments are made over a 12-kilometer railroad to Pomaras on the Rio Guardia, navigable to the ocean. Recent statistics are not available, but the 1914 production was 265,987 tons of ore, of which amount 49,665 tons was leached, producing 1029 tons of 72.3-per cent. cement copper, equal to 1,636,727 lb. of copper. The remaining 218,252 tons of ore was shipped as pyrite. Reserves were estimated by the Government officials at 500,000 tons in 1916.

The Ajustral or Minas de San Joas de Deserts, situated 18 miles southwest of Beira, is the second mine of importance in the country. It contains six veins of copper-bearing pyrite in schist, the ore carrying about 1 per cent. copper. The veins are opened by six shafts to a depth of 120 meters. Operations have been suspended since 1915 owing to high costs and unstable conditions and the mill and smelter are in disrepair. The 1914 output was 165,465 tons of ore, from which 39,539 tons of ore carrying 2 to 5 per cent. copper was sorted and shipped, besides 1229 tons of 77-per cent. matte.

The following table shows the exports from Spain, in metric tons:[1]

	January–December.			
	1915.	1916.	1917.(a)	1918.
Copper, precipitate	10,443	11,432	11,655	9,855
Black and old copper, bronze, brass	254	1,736	*Nil*	*Nil*
Copper ingots	15,685	12,634	17,966	10,938
Copper bars	372	261	53	.....
Copper sheets and nails	.....	21	3	.....
Brass sheets	.....	242	512	.....
Rolled copper, brass and bronze	267	1,196	593	.....
Copper ore over 2½ per cent. Cu	16,340	21,239	15,846	.....
Copper ore under 2½ per cent. Cu	13,179	24,386	15,480	22,341

(a) January–November.

Venezuela.—While copper occurs at many places in this country, there was but one producer in 1918, the South American Copper Syndicate, Ltd. This company operates the Aroa mines, once worked by Spaniards, but under British control from 1862 to 1880 and idle from then until 1895. The output was 19,900 metric tons in 1918, compared with 41,289 tons of 7-per cent. ore in 1917. The Aroa mines are in Yaracuy and have their own railway to the port of Jucacas, where it transfers the matte to barges to be loaded on ships a mile out from the wharf.

[1] *Metal Bull.*

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The mines are well equipped with machinery and a small matte-smelting plant, with ample water power available.

At Cumaragua a Venezuelan company produced 580 short tons of ore in 1917, mined from pockets of carbonate ore along a mineralized belt. No definite vein had been found at last reports.

The Syndicata Aleman of Caracas owns the Santa Ysabel copper-zinc prospects south of Villa de Cura in Aragua. Though showing an ore shoot where two veins intersect, the 11 tons of ore shipped to the United States in 1917 assayed but 4.6 per cent. copper and 10.22 per cent. zinc. About $32,000 has been spent at the locality without proving up the ground either way. The Venezuela records show 37 copper claims, totaling 12,500 acres. One of them, the Camburito in the Aroa district, is owned by J. C. Price, manager of the Bolivian Railway Co., who sent a trial shipment out in 1917. The Charco Pato claims on the Caribbean Coast also mined a few tons of copper carbonate in 1918 and some development work was done on a claim near Carupano.

The Metallurgy of Copper in 1918

By L. S. Austin

Progress in 1918.—Up to December, 1918, in order to supply insistent war demands, high wages were paid, and yet labor was scarce and less efficient. This condition, as well as decreased production, has resulted in increasing expenses greatly, especially in electrolytic refining, where costs have been doubled over those prior to the war.

Reverberatory tonnage has been increased and the grade of the resultant matte raised by increase of roasting equipment. Such increase in the grade of matte results in a reduction of converter work and of other costs. In roasting we know that elimination of sulphur is speedier when the ore drops through the flame than when the ore is rabbled. The drawback to making such drops has been the flue-dust produced. However, such flue-dust is now well recovered by the use of larger settling flues and Cottrell installations, and hence one may, by increasing the height and number of hearths, increase the roasting effect. Delivery of the calcine at high temperature to the reverberatory has increased its output because of the shorter time needed to heat such a product to melting temperature. When using either powdered coal or oil in the reverberatory increased output has resulted from increasing the area of its outlet flue. Also, for instantaneous ignition and burning of the fuel, it has been found better to deliver both air and fuel at lower pressure but in large quantity. This means that the flame begins at the nozzle and

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disappears nearer the fire-end. Of course such intense flame is harder on the furnace roof. Moreover, to increase such supply of air and fuel, double banks of burners, other air-ports, and hotter calcines have all aided. Since the melting takes place nearer the fire-end, there remains a larger area available for better settling out of the matte from the slag. As a result, tonnage per furnace has been doubled, and even so, with less fuel per ton of ore smelted. Powdered coal is rather supplanting oil, because it is cheaper, and because the combustion can be so closely controlled that but little excess air is used and the escaping gas contains 16 to 18 per cent. CO_2. The Garr silica gun or injector has been applied to the Smith-Pierce converter. It blows in silicious material at one end and distributes it over the surface of the molten bath. At Anaconda the new Cottrell installation removes the arsenic present in the flue-dust, and the high stack carries the smoke more than 1000 ft. above the surrounding country, thus removing the menace to agricultural operations.

Plant Construction in 1918.[1]—At the Hayden smelter the American Smelting & Refining Co. installed a coal-crushing plant and a new stack. At its Humboldt plant the Consolidated Arizona Copper Co. completed a new roaster plant, costing $300,000. It included four Wedge furnaces, with Cottrell electrostatic treaters. Also a converter stack, 190 ft. high, and costing $20,000, was built. At Jerome, Ariz., the United Verde Extension Copper Co. has the blast furnace in operation and two reverberatories under construction. At Anaconda, Mont., the Anaconda Copper Mining Co., on Dec. 14, 1918, completed its new stack 585 ft. high. At the Anyox smelter the Granby Consolidated Mining, Smelting & Power Co. completed smelter improvements, including two 20-ft. Great-Falls-type converters.

Copper for Shipbuilding.[2]—It is computed that a 10,000-ton ship would need at the outside 90,000 lb. of copper and 150,000 lb. of brass, or reckoning the brass as being two-thirds copper, a total of 190,000 lb. of copper. From this is made brass and copper tubes, condenser tubes, wire, sheet copper, propeller blades, bearings and numerous castings. This total of 190,000 lb. does not include the copper in valves, cocks, pumps and auxiliary fittings, purchased from other companies.

Copper Smelting Works of North America.[3]—In the accompanying table the yearly capacity in tons is given in terms of new ore and flux, but not including fuel or by-products. In this is included ore charged to the converters. The smelting companies of Lake Superior treat mass-copper and copper concentrate.

[1] *Eng. Min. Jour.*, **107**, 71.
[2] *Eng. Min. Jour.*, **105**, 394.
[3] *Eng. Min. Jour.*, **107**, 47.

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COPPER-SMELTING WORKS OF NORTH AMERICA[1]

Company.	Situation of Works.	No. of Blast Furnaces.	Annual Capacity.	No. of Reverberatory Furnaces.	Annual Capacity.	No. of Converters.	Annual Capacity in Ore. (a)
American Smelting and Refining Co.	Aguascalientes, Mex.	6	480,000			4	(b)
American Smelting and Refining Co.	Perth Amboy, N. J.	1	90,000			3	(b)
American Smelting and Refining Co.	Omaha, Neb.					2	(b)
American Smelting and Refining Co.	El Paso, Tex.	4	400,000	4	580,000	4	(b)
American Smelting and Refining Co.	Matehuala, S. L. P., Mex.	4	435,000				
American Smelting and Refining Co.	Hayden, Ariz.			4	580,000	4	(b)
American Smelting and Refining Co.	Sasco, Ariz.	2	300,000			2	
American Smelters Securities Co.	Garfield, Utah	4	800,000	7	1,022,000	9	(b)
American Smelters Securities Co.	Tacoma, Wash.	3	560,000	1	144,000	4	(b)
American Smelters Securities Co.	Velardeña, Dgo., Mex.	3	250,000				
Anaconda Copper Mining Co.	Anaconda, Mont.	3	1,750,000	9	1,980,000	7	105,000
Anaconda Copper Mining Co.	Great Falls, Mont.	4	675,000	2	210,000	2	49,000
Arizona Copper Co.	Clifton, Ariz.			3	360,000	3	
Compagnie du Boleo	Santa Rosalia, Mex.	7	700,000				
Calumet & Arizona Mining Co.	Douglas, Ariz.	2	633,500	5	997,500	6	350,000
Canada Copper Corpn. (f)	Greenwood, B. C.	3	912,500			2	52,000
Cananea Consolidated Copper Co.	Cananea, Son., Mex.	8	868,000	2	153,000		
Consolidated Arizona Smelting Co.	Humboldt, Ariz.	1	90,000	1	160,000	6	35,000
Consolidated Mining and Smelting Co.	Trail, B. C.	4	207,000			2	5,000
Copper Queen Branch, Phelps-Dodge Corpn. (c).	Douglas, Ariz.						
Detroit Copper Mining Co. (c)	Morenci, Ariz.						
Ducktown Sulphur, Copper and Iron Co.	Isabella, Tenn.	2	150,000				
East Butte Copper Mining Co.	Butte, Mont.	2	225,000			4	5,000
Granby Consol. Mining, Smelting and Power Co.	Grand Forks, B. C.	8	1,400,000			3	7,000
Granby Consol. Mining, Smelting and Power Co.	Anyox, B. C.	4	1,330,000			5	110,000
International Nickel Co. of Canada (e)	Copper Cliff, Ont.	8	1,166,000	1	174,000	6	64,500
International Smelting Co.	Tooele, Utah			5	500,000	5	50,000
International Smelting Co.	Miami, Ariz.			4	700,000	5	50,000
Ladysmith Smelting Corpn. (f)	Ladysmith, B. C.	2	236,250				
Mammoth Plant, U. S. Smelting, Refining and Mining Co.	Kennett, Calif.	5	700,000			2	28,500
Mason Valley Mines Co.	Thompson, Nev.	2	419,192			2	16,930
Mazapil Copper Co.	Concepcion del Oro, Zac., Mex.	2	144,000				
Missouri Cobalt Co.	Fredericktown, Mo.	1	35,000				
Mond Nickel Co.	Coniston, Ont.	4	700,000			4	60,000
Mountain Copper Co.	Mococo, near Martinez, Calif.			1	60,000	2	5,500
Nevada Consolidated Copper Co.	McGill, Nev.			5	900,000	4	20,000
Nichols Copper Co.	Laurel Hill, N. Y.	1	100,000			4	
Norfolk Smelting Co.	West Norfolk, Va.	1	87,500			2	5,250
Phelps-Dodge Corpn., Copper Queen Branch	Douglas, Ariz.	10	1,596,000	3	490,000	8	106,400
Phelps-Dodge Corpn., Morenci Branch	Morenci, Ariz.	1	193,200			3	9,800
Old Dominion Co.	Globe, Ariz.	3	450,000			2	8,500
Orford Works, International Nickel Co.	Constable Hook, N. J.	2	94,500			3	

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Penn Mining Co.	Campo Seco, Calif.	.....	.....	2	72,000	1	42,000
Santa Fe Gold and Copper Co.	San Pedro, N. M.	1	45,000	.....	.....	.....	.....
Shannon Copper Co.	Clifton, Aris.	2	400,000	.....	.....	2	5,612
Swansea Consol. Gold and Copper Mining Co. (*f*)	Bouse, Ariz.	1	190,000	.....	.....	2	.....
Tennessee Copper Co.	Copperhill, Tenn.	5	1,000,000	.....	.....	2	15.000
Teziutlan Copper Mining and Smelting Co.	Teziutlan, Puebla, Mex.	2	350,000	.....	.....	3	.....
Cia. Metalurgica de Torreon	Torreon, Coah., Mex.	2	175,000	.....	.....	2	.....
U. S. Metals Refining Co.	Chrome, N. J.	2	200,000	.....	.....	3	(*b*)
U. S. Smelting Co. (*f*)	Midvale, Utah	.....	.....	.....	.....	.....	.....
United Verde Copper Co.	Clarkdale, Ariz.	4	685,000	3	400,000	6	50,000
United Verde Extension Mining Co.	Clarkdale, Ariz.	1	175,000	1	175,000	3	350,000
Wanakah Mining Co. (*d*)	Ouray, Colo.	2	105,000	.....	.....	.....	.....
Western Smelting & Power Co.	Cooke, Mont.	1	110,000	.....	.....	.....	.....

[1]From *Eng. Min. Jour.*, Jan. 11, 1919.

(*a*) Raw ore smelted as flux. (*b*) Included in furnace tonnages. (*c*) See Phelps-Dodge Corporation. (*d*) Plant sold to Ouray Smelting and Refining Co. (*e*) Formerly Canadian Copper Co. (*f*) Not in operation.

LAKE SUPERIOR SMELTING WORKS

Company.	Situation of Works.	No. of Blast Furnaces.	Annual Capacity.	No. of Reverberatory Furnaces.	Annual Capacity.
Calumet & Hecla Mining Co.	Hubbell, Mich.	1	75,000	21	150,000
Lake Superior Smelting Co.	Dollar Bay, Mich.	1	50,000	7	75,000
Michigan Smelting Co.	Houghton, Mich.	1	45,000	5	85,000
Quincy Smelting Works	Hancock, Mich.	1	20,000	4	35,000

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DETAILS OF SMELTING PLANTS AND METHODS

Preparation of Powdered Coal.[1]—The Nevada Consolidated Copper Co., McGill, Nev., has erected a plant for pulverizing and distributing 600 tons of coal daily to five reverberatory furnaces. The cost of the powdered coal depends on the amount of moisture to be removed before pulverizing, as well as upon the cost of the coal delivered at the plant. Coals containing about 35 per cent. volatile matter, 50 per cent. carbon, 8 per cent. or less of ash, and 2 per cent. or less of moisture are preferable; with 25 per cent. ash and 5 per cent. sulphur they cause trouble. Coal dried out to 1 per cent. or less of moisture, and lignite with 5 to 8 per cent. of combined moisture, can be readily ground and fed to the furnaces. It should be ground so that 95 per cent. of it will pass a 100-mesh screen and 70 per cent. a 300-mesh sieve. On a basis of 200 tons daily for coal of 7.5 per cent. moisture, the present cost for drying and pulverizing will be between 30 and 40 cts. per ton, not including overhead expenses, interest and depreciation.

Grate versus Powdered-coal Firing.[2]—W. G. Wilcox in his paper cites the case of a high-ash Illinois coal where a consumer, using over 100 carloads of coal daily, both on stokers and by hand-firing, had 25 to 35 per cent. of unburned coal in the ashes, being an actual fuel loss of 4.6 to 6.5 per cent. In gas-producer operation there is at least 20 per cent., and when using poor, wet, fine coal, as high as 55 per cent. of unburned carbon in the ash. In general also, the carbon loss increases with the ash content. Certain coals burned on grates cause much trouble from clinkering. Thus, in the case of a Colorado coal having 6.6 per cent. ash, this ash melts, runs down the grates and freezes there, while the coal disintegrates and chokes the fire.[3]

In turning from hand-firing to powdered-coal burning, due to the great efficiency of the furnace, the economies are far greater than can be figured from the losses above mentioned. It is possible by it to secure the maximum flame temperature with a correspondingly increased rapidity of heat transfer. The more rapid the transfer of heat the greater the capacity, and consequently the greater the efficiency of the furnace. To attain this, the supply of both air and powdered coal should be capable of nice control; also there must be an intimate mixture of both. The rapidity of the reaction between the powdered coal and the air depends first upon its fineness. Thus an inch cube of coal, so ground that 85 per cent. of it will pass 200-mesh, has a surface 300 times that of the original cube, and so is 300 times more active in burning. This increased speed

[1] *Min. Sci. Press*, **117**, 325; *Bull. Am. Inst. Min. Eng.*, **136**, 955; **144**, 1771; *Trans.*, **61**.
[2] *Min. Sci. Press*, **116**, 847, 849; **117**, 325.
[3] In reverberatory practice, burning coal on grates, the cleaning of the fires causes much loss of unburned carbon. In fact, at the Washoe plant, this caused a 10-per cent. loss of unburned cinder that was later recovered at a coal-washing plant. L. S. A.

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increases the rapidity of the heat evolution, and so quickly raises the temperature of the rest of the material. This rise, so much more rapid than the normal rate of combustion, doubles the velocity of combustion for each rise of 10° C. Thus greater surface exposure and higher temperature are superimposed, so that pulverized fuel burns hundreds of times faster than lump coal. The next important requirement is the intimate mixture of the fuel and the air, so that each small particle of coal will be surrounded by the proper amount of air. To accomplish this the velocity at which the fuel is injected must be slowed down to the point where combustion will begin immediately at the entrance of the mixture into the furnace. In older practice the velocity was so high that the flame did not begin until a point 4 to 6 ft. from the burners. Moreover, high pressure not only slows down the rate of combustion, but, due to the erosive action of the gases, has a destructive effect upon the brickwork of the furnace. There is, too, a fluxing action on the melting ash, the slagged material being carried along mechanically. With lower velocity the coalesced particles are larger, and with a small change in the direction of the flame drop out upon the molten bath instead of being deposited in the flues and upon the waste-heat boilers.[1] The velocity of combustion again depends upon the temperature in the zone of combustion. The kindling temperature of the coal-and-air-mixture is higher than that of oil or gas, hence the heat at the firing end must be high. Indeed it is so for a regularly working reverberatory, where, except in starting, the brickwork receives and radiates its heat freely. That an intimate mixture of coal-dust and air at low velocity develops instantaneous flame is shown in the case of a reverberatory furnace at Florence, Colo. Here, coal burned at the rate of one ton per hour develops a flame which vanishes within 6 ft. of the burner, combustion being complete at that point. Samples of the gases taken at 5 ft. from the burner show CO_2 as high as 16 per cent. It is also possible by proper adjustments to produce a flame which will spindle out to 100 to 120 ft.; but, where the mixture is intimate, this can only be accomplished by supplying insufficient air. Under "Smelters" will be found other examples of the practice in using powdered coal.

Due to the attitude of labor and the scarcity of skilled operatives it is difficult to fire furnaces efficiently either by hand, by using mechanical stokers or by producers. We therefore welcome powdered-coal firing with its ease of control, its pleasanter conditions and its constant efficiency of operation, which can be accomplished by properly trained and older men.

[1] It is contended that fine grinding of the coal brings it within the realm of the colloid. A colloid consists of but few molecules and burns like a gas. It likewise powerfully absorbs oxygen from the air, even to a greater degree than ordinary charcoal, and will take up 9¼ times its own volume of oxygen. Thus, a great store of oxygen exists ready to effect instantaneous combustion on being brought to flame temperature.

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Smelting Plants Using Powdered Coal.[1]—The following plants are using powdered coal as fuel:

American Smelting and Refining Co., Garfield, Utah.
American Smelting and Refining Co., Hayden, Ariz.(a)
American Smelting and Refining Co., Maurer, N. J.
American Smelting and Refining Co., Tacoma, Wash.(a)
American Smelting and Refining Co., Mexico.
Anaconda Copper Mining Co., Anaconda, Mont.
Anaconda Copper Mining Co., Great Falls, Mont.
Braden Copper Co., Valparaiso, Chile.
Canadian Copper Co., Copper Cliff, Ont.
Furukawa Mining Co., Tokio, Japan.(a)
Lake Superior Smelting Co., Dollar Bay, Mich.
Nevada Cons. Copper Co., McGill, Nev.
River Smelting and Refining Co., Florence, Colo.
Société des Mines des Cuivre de Naltagua, Chile.
United Verde Copper Co., Clarkdale, Ariz.(a)
United Verde Extension Mining Co., Jerome, Ariz.
(a) Under construction.

Forehearth at Santa Rosalia, Mex.[2]—Lindsay Duncan describes the reverberatory forehearths of the four-furnace plant of the Compagnie du Boleo, which smelts an ore high in silica and alumina, low in iron and

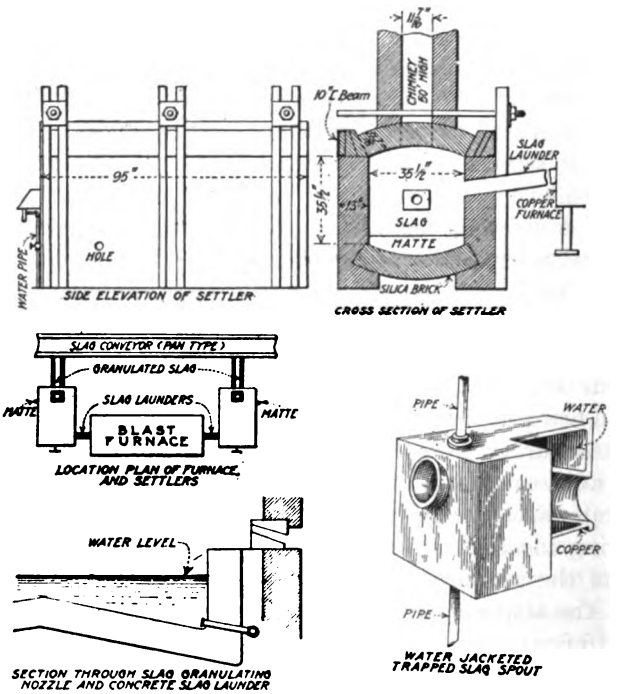

FIG. 1.—Details of reverberatory forehearths.

sulphur, with no flux available, and yielding a black copper of 98 per cent. and a matte of 62 per cent. copper. To do this successfully a narrow smelting zone is maintained with a temperature of 1500° C. Referring

[1] *Eng. Min. Jour.*, **106**; *Gen. Elec. Rev.*, May, 1918.
[2] *Eng. Min. Jour.*, **106**, 534; private communication; MINERAL INDUSTRY, **26**, 189 (1917).

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to Fig. 1 it will be seen that each blast furnace of 250 tons capacity has a forehearth at either end, about 3 ft. by 6 ft. inside dimensions, with a chimney at one end 50 ft. high, and heated by fuel-oil to keep its contents molten, so that any entrained matte may settle out to be tapped off from time to time. The bulk of the matte and black copper is withdrawn, however, from the furnace crucible as it accumulates. Both the furnace and the forehearth are provided with a water-jacketed trapped slag-spout as shown in the cut. The slag, flowing from each forehearth, falls into a concrete granulating launder and is swept into a horizontal pan-type conveyor, then is raised by an elevating conveyor to discharge into a storage-bin. From the bin it can be withdrawn for delivery through a slag-launder to a hopper-bottom barge, this being towed out to sea and dumped, or in bad weather it may deliver to a Bleichert tramway. The furnaces are close to a sea-wall with furnace floor 5 ft. above the sea-level. The bottom of the pan-conveyor trench is but 12 in. above the sea. As the result of using an oil-heated forehearth the slag, formerly running 1.2 to 1.8 per cent., was reduced to 0.9 per cent. copper. There was a metal recovery of 5000 to 6000 lb. of copper per day for the entire plant.

Slag and Matte Handling at Granby Smelter.[1]—Eight blast furnaces have a slag-launder leading from each pair of furnaces to the bins which receive the granulated slag. From the front of each furnace the slag is led through a train of three settlers to a settler which combines the flow of both, then through a fifth to the slag-launder. The doubled slag stream assures sufficient heat to keep these final settlers open.

Most of the matte, of say 31 per cent. copper, is collected and tapped off at the first settler. From the fourth and fifth settlers, tapped after several days, the grade may be as much as 50 per cent. copper. Under the best conditions of the blast furnaces a matte is made that, on arriving at the first settler, contains a product that chills out. This product accumulates in the settler as a sow of metallic iron and low-grade matte, so that at the end of two weeks it is necessary to remove it. This plan of using settlers in series is preferred to using a single large settler. A settler of 18 by 10½ ft. has been tried, but the series system is preferred because of cleanness of slag and ease of operation. The settlers are round with a cast-iron bottom in two halves. On this is placed and clamped to the bottom a water-jacketed shell 6 ft. 9 in. in diameter at the top, 7 ft. 3 in. at the bottom, and 3 ft. 6 in. deep. Into this is lowered a water-jacketed mould of such size and form as to leave a space 7 in. wide above and 14 in. at the bottom. The joints having been clayed up, silicious slag is poured into the space to form a slag-wall or lining. The mould is then withdrawn. The bottom of the settler is no more than

[1] *Min. Sci. Press*, 116, 819.

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a 2½-in. layer of bricks, bedded in sand. The settler-shell is provided with a welded water-jacketed matte-tap arranged with fire-brick at the tapping point through the slag lining.

When a change has to be made in the settlers, the used one is picked up by an overhead crane and set aside, and at once replaced by a new one standing ready, all with little or no interruption of furnace operation. The clamps are now knocked away from the used settler and the shell lifted off, leaving the stripped contents ready to be broken up and sent to converters.

With eight furnaces in blast the granulating is done at the ends of the four launders, using a ⅝ by 2-in. nozzle to produce a horizontal flattened water-jet, which strikes and granulates the molten slag as it flows into the granulating launder. To granulate the two tons of slag produced per minute, there is used 1600 gal. of water at 50 lb. pressure, and 2800 gal. of jacket-water to aid in carrying the granulated slag along the launder.

The cheapest and most durable lining for the launders are slag blocks made in cast-iron two-part moulds to produce a block 18 by 24 by 3 in. thick, reinforced by expanded metal. These line the sides and bottom of the launders, leaving a clear width of 18 in. A slag of 43 per cent. silica, 16 iron and 20 per cent. lime is satisfactory. When cast, the moulds are covered to a depth of about 12 in. with flue-dust, so that they may cool gradually, and so avoid cracking. When angular pieces are needed a steel plate is set to cut out the space required.

The granulated slag and water is received in a hopper-bottom four-compartment bin, 20 by 64 ft., and of 250 tons capacity. Here the water is drained off and the slag discharged in regulated flow through the bin-chutes upon a horizontal belt-conveyor, which runs beneath and parallel to the long axis of the bin.

There are two slag-dumps, the north and the south, the north one commonly used, the south one running during repairs or changes of the north system.

Including the belt at the bin, there are six conveyor sections in the north and four in the south system. It is aimed to make each section 310 ft. long, with a 30-in. troughed conveying belt. The motion of the belt of the bin section can be reversed so as to deliver either way. From the bin section the conveying belts rise at an angle of 18½°, the first two sections supported on trestles, and the slag building up at the delivery ends. Thence the conveyors are advanced on the forming slag-dump on a trestle about 8 ft. above the slag. The last or discharge section of the conveyors has an S-drive placed beneath the permanent head drive, the slag being delivered over the end of this section. This is called a telescopic belt because its down-hill end extends 50 or 60 ft. directly

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beneath the preceding section, while the discharge end is supported on a carriage having a free movement of 20 feet. When it is necessary to advance the discharge, the carriage can be jacked forward without disturbing operations, as there is unused belt to pull up beneath the preceding section. When the spare belt is used up, the rear take-up car is dropped back, spare belt inserted, and operation resumed. At the north dump Nos. 4 and 5 sections were formed in this way, and No. 6 is now in process of formation. The bin section is driven by a 30-hp. motor, the inclined sections by a 75-hp. one. Running empty 16 hp. is needed; when loaded, 64 hp.; it is best therefore to run the conveyors fully loaded. When running eight furnaces 2880 tons of slag (80 to 85 per cent. of the charge) is made daily, and all the slag on an 8-hr. shift is handled in about 3½ hours' time. Thus is saved both power and wear on the belts. The belts are run at the rate of 500 ft. per min., except the discharge belt, which has a velocity of 700 ft. per minute. The object of this is to move the old belting worn thin and narrower to the discharge end, driving it faster to better take care of its load. In one case a belt, before it was moved to the last section, carried 2,250,000 tons of slag, in another case 1,800,000 tons. On the six sections of the north dump there is 3200 ft. of belt, on the four south sections 1900 ft. The cost per ton of ore for handling its slag, including power, repairs, maintenance, labor and extension was 3.8 cts. in 1915 and 1916 and 5.6 cts. in 1917. Up to 1912 the slag, in molten condition, was handled and dumped in pots, using small locomotives. Due to shortage of dumping room the present system was substituted.

Treatment of Mixed Concentrates.[1]—T. A. Rickard discusses the handling, sampling, and roasting of the product of the Arthur Mill of the Utah Copper Co., a mixture of flotation and table concentrates, which in 1917 averaged Cu, 14.82 per cent.; Fe, 26.79; insol., 21.69; moisture, 13.6 per cent.[2] Formerly the two kinds of concentrates were separately shipped, the first containing 20 per cent. copper with 20 to 25 per cent. moisture, the second 12 copper and but 8 per cent. moisture. Because of the wet and sticky nature of the mixture, it is costing by contract $14.35 per car to unload a 70-ton car. For the moisture sample a scoop is used which takes a cut from the top to the bottom of two holes dug through the load at one-third the distance from the center to the end of the car. For the regular sample every tenth shovel is set aside while unloading. The material as unloaded drops into receiving hoppers and is conveyed by belt to be distributed by a traveling tripper to the bedding bins 20 ft. wide by 540 ft. long. A 10-per cent. addition of 50-per cent. silica ore

[1] *Min. Sci. Press*, 117, 853.

[2] The flotation concentrate contains 16.7 per cent. alumina, and its insoluble matter 16.9 per cent. of silica.

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is made here. When drawn off from the bedding bins to the charge-cars trouble is experienced, since the material has to be jarred and poked by hand to cause it to slide out into the roaster hoppers. At these hoppers the trouble continues, so that even when the best type of feeder is used, such as the Stevens-Adamson apron-feeder, the ore tends to bridge in the hoppers, needing more hand labor to poke it down, and even then disturbing regularity of operation.

Nodulizing Fine Concentrate.[1]—At the smelter of the Braden Copper Co., a sandy concentrate, containing 17 per cent. silica, is heated to 950° C. to agglomeration as nodules in rotating cylinders sloping 1 in. to the foot to the discharge end. In nodulizing the sulphur is reduced from 28 per cent. to 18 per cent. The hot material is transported by pan-conveyor to the blast-furnace charge-hoppers. The Canadian Copper Co., at Princeton, B. C., uses a similar kiln or cylinder, 7 ft. in diameter by 125 ft. long. The kiln is driven by electric power and fired by pulverized coal. It is considered that a 100-ft. kiln would be better, and would have a tonnage of 100 to 125 tons daily. The nodules retain 82 per cent. of the original sulphur, which in this case is all needed in the following blast-furnace smelting. At Chrome, N. J., flotation concentrate, containing 30 per cent. sulphur, from the El Cobre mine in Cuba, has been similarly nodulized, using 6 to 7 gal. of fuel-oil per ton of concentrate. The nodules are preferably charged to the blast furnace cold. They carry 14 per cent. sulphur. They are nearly all less than ½ in. in size, but only 5 per cent. of them is finer than 16-mesh.

Roasting Furnaces at the Garfield Smelter.[2]—These comprise in all 48 furnaces, viz:

Ten Herreshoff seven-hearth furnaces, 19½ ft. diameter of shell;
Sixteen McDougall six-hearth furnaces, 18 ft. diameter of shell;
Fourteen McDougall six-hearth furnaces, 19½ ft. diameter of shell;
Eight Call-Wagstaff eight-hearth furnaces, 19½ ft. diameter of shell.

The roaster feed contains 14 to 16 per cent. copper and 29 to 30 per cent. sulphur, and yields in the reverberatory a matte of 42 per cent. copper.

Coal-dust-fired Reverberatory Furnaces at the Naltagua Smeltery.[3]—The Société des Mines de Cuivre de Naltagua, due to the high war prices for coke, have changed from blast-furnace to reverberatory smelting where the cheaper native coal can be utilized. They smelt an ore containing 6 per cent. of copper. The company has put in two furnaces, each of 55 by 17 ft. hearth dimensions, for powdered-coal firing; also the necessary coal-grinding plant. This has a capacity of 2½ to 3 tons per

[1] *Min. Sci. Press*, **115**, 44; **117**, 857; *Min. Jour.*, Aug. 1, 1918.
[2] *Min. Sci. Press*, **117**, 855.
[3] *Eng. Min. Jour.*, **106**, 21.

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hour, grinding the coal so that 65 per cent. passes a 200-mesh screen. The coal used contains 16 per cent. ash, 36 volatile matter and 47 per cent. fixed carbon, and has a heating value of 6000 calories per kilogram. The gases from the reverberatories heat the three Erie City waste-heat boilers of 300 hp. each, generating steam for power purposes about the plant. This new equipment, installed in 1917, has been in operation through the year.

Reverberatory Construction and Methods.[1]—Experimental work, started at the Copper Queen smelter by Capt. H. H. Stout, the superintendent, has resulted in improved reverberatory practice at the two Douglas plants and at the El Paso smelter, elsewhere described.

The higher the temperature of the calcines the greater was the economy of fuel in reverberatory smelting. At El Paso, where the temperature of the charge was as low as 100° C., there was a fuel consumption of 0.95 bbl. of oil per ton. At Douglas the use of hot calcines of 260° C. gave a fuel ratio of 0.77 bbl. per ton of charge; at 460° C. it was 0.59 barrel. These figures enable the plotting of a graphic curve indicating that were it possible to charge calcines at 625° C., not more than 0.50 to 0.45 bbl. would be needed per ton of charge. Recent determinations show that with an initial calcine temperature of 700° C. there is a loss of 40° C. in dropping to the calcine hopper, of 100° thence to the charge-car, no loss is transit, 85° when dropped from the car into the reverberatory hoppers, and finally a loss of 60° in the hoppers, a total of 285°, so that the charge-temperature, when dropped into the melting zone, is 515° C.[2]

Reverberatory Furnace at the Copper Queen Smelter.—Figure 2 shows the sectional plan and elevation of this 100 by 21-ft. 2-in. furnace. From the fire-end the roof slopes downward 1 ft. in the first 20 ft. and is carried level thence to the up-take. Because of the low draft in the up-take this was increased from 33 to 70 sq. ft. area, and the verb widened to 11 ft., as shown. These changes reduced the gas velocity from 75 to 40 ft. per second. There are two banks of burners, seven in one row, six in the other, using injection air at 35-lb. pressure. The oil, heated to 125° C., is delivered at 80-lb. pressure to suppress volatilization of the hydrocarbons, and, when injected, expands with explosive violence, instantly heating and volatilizing the rest of the oil. Of the total air 10 per cent. is used for injection; the remainder enters by ports at the burners, and this flow is regulated by port-dampers. With a flame length of 35 ft., which begins at the nozzles, 1 lb. per min. is burned for each 26 cu.

[1] *Eng. Min. Jour.*, **106**, 140, 142.

[2] The roaster charge at the Copper Queen was composed of concentrates 79.5 per cent., Sasco flue-dust 16.1 and silicious ore 4.4 per cent., averaging 26 per cent. sulphur and roasted without fuel to leave 10.5 per cent. in the calcines. Each roaster is handling 60 to 70 tons per day. Captain Stout is planning to make 11-hearth roasters out of the present 6-hearth ones, bringing up the tonnage to 130 tons per day. He figures on the more energetic roasting which results from showering the ore charge from hearth to hearth.

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ft. of available combustion space, reckoned to the end of the flame. The limiting factor in fuel consumption, however, is the volume of air that can be drawn through the old waste-heat boilers and flues. One can infer that the reverberatory furnace is primarily a combustion chamber, with the melting, the furnace reactions and the separation of matte secondary factors. On an average output of 680 tons, the oil used is 0.55 bbl. per ton, while on a two-day run 730 and 740 tons has been put through with a consumption of 0.45 to 0.47 bbl. per ton. In operation, by the end of five weeks, the wall above the skimming bay was nearly burned through, due to lack of control in the fire zone. The boiler-tubes were also burning out. As at Anaconda, a scum or blanket of unfused material is allowed to form on the molten bath which holds back the unfused slag at the hotter part of the furnace. A limpid slag issues from beneath

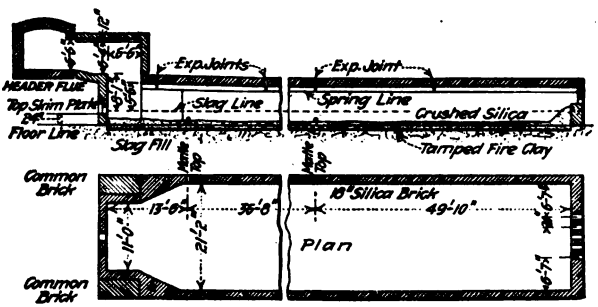

FIG. 2.—Copper Queen reverberatory furnace, Douglas, Ariz.

this blanket in continuous flow, and this is found to be cleaner than in intermittent flow. With a 30-per cent. matte the slag will contain 0.30 to 0.35 per cent. copper. Attempts to clean ordinary magnetic converter slag, of about 22 per cent. silica, by pouring it molten into the reverberatory, have failed because such slag is heavier than the furnace slag, and sinks beneath it, and hence is unaffected by the furnace reactions. A light slag of 40-per cent. silica has now been made in the 12-ft. Great-Falls-type converter by blowing crushed ore into the converter continuously from start to finish of the blow. The silica thus added keeps the converter cool enough for good working.

At the Calumet and Arizona plant[1] the experience was similar. On their 19 by 100-ft. reverberatory furnace, prior to 1918, the best result was 400 tons of charge, using 0.75 bbl. of oil per ton of charge. The furnace uptake was now increased from 30 to 70 sq. ft. and the tonnage rose to 650 tons per day. By proper adjustment of the burner-hole dampers the air supply was so increased and perfected that 500 bbl. of

[1] *Eng. Min. Jour.*, **106**, 141.

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oil was burned, or 200 bbl. more per day, the amount of charge smelted then rising to over 900 tons per day.

The flame was confined to the first 30 ft. of the furnace with a resultant maximum temperature of 1320° C. at the front of the furnace. The charge material is all side-charged, 90 per cent. of it at the first 30 ft. of the furnace. As at the Copper Queen smelter, much attention is given to delivering the calcines as hot as possible. It is mostly less than ¾-in. size, 61.7 per cent. being less than ¼-in. size. In operation furnaces No. 2 and No. 4, running respectively 130 and 157 days, showed outputs of approximately 700 tons of dry solid charge daily, using 0.7 bbl. of oil per ton of such charge, and treating up to 100 tons of molten slag besides. The draft in the uptake was about 0.2 inch. For the best 30 days running the output rose to nearly 800 tons, using 0.62 bbl. of oil per ton of charge. On a record day there was smelted in No. 2 furnace 921 tons of charge, using 0.55 bbl. of oil per ton of charge. Analysis shows a slag (including converter slag added) to contain SiO_2, 35.2 per cent.; Al_2O_3, 7.2; FeO, 46; CaO, 5.6; and copper 0.45 per cent., this latter figure being rather high when producing a matte of 25.9 per cent. copper. We note that at the Tacoma smelter, by increasing the air supply, reverberatory output has been raised to 600 tons per day, with an oil consumption of 0.63 bbl. per ton. At the Garfield smelter the output per furnace is 600 tons per day, using 15 per cent. powdered coal blown through flattened nozzles.

Reverberatory Furnace for Treating Converter Slag.[1]—At the Washoe Reduction Works, Anaconda, a large furnace placed in the converter building is now treating 1000 tons daily of material, a little over 50 per cent. of it being molten converter slag. The rest of the charge is a mixture of calcines and raw concentrates, together with silicious fettling material, the whole yielding an irony slag low in silica. The fuel is powdered coal, about 8 per cent. of the charge. In order that the magnetite in the molten converter slag may be reduced to FeO by the sulphur-bearing concentrates, a reasonably good mixture of the two must be made. The fettling material is separately fed along the furnace sides.

Ventilating Calcine Loading Tunnels.[2]—At Anaconda, when the calcine is drawn off into the calcine-cars, much sulphur smoke is evolved. To speedily remove this, a sheet-metal stack or flue is carried well above the roaster building at the back end. This creates a draft along the tunnel, sweeping away the smoke.

Ores Suited to Side Fettling of Reverberatory Furnaces.[3]—Forest Rutherford describes the course of improvement in this method of working. A

[1] *Eng. Min. Jour.*, **106**, 144.
[2] *Eng. Min. Jour.*, **106**, 134.
[3] *Eng. Min. Jour.*, **106**, 109.

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fettling material of barren quartz resulted in floaters, in a slag of 0.63 copper on 45-per cent. matte, and in low tonnage. Substituting a siliceous ore containing copper as carbonate resulted even worse, the slag jumping to 0.75 and 1.0 per cent. in copper, due to presence of shot-copper in it. Floaters and scum also formed. Finally a self-fluxing copper-sulphide ore was tried, containing 8 to 12 per cent. moisture. The slag then dropped 0.49 per cent. copper with a 36-per cent. matte, the floaters disappeared and the tonnage increased 60 tons daily per furnace. Today hot calcines are side-fed, but where these are not to be had, the above principles hold.

New Type of Great Falls Converter.[1]—In operation, large converters tend to sag, thus raising the gears out of line. To prevent this the two new 20-ft. converters, at Anyox, B. C., manufactured by the Traylor Engineering Co., are reinforced by heavy angle-plates and a ribbed top. The gears also are made slightly beveled, so that in case of slight sagging they may straighten up. The matte from the blast furnaces, of whatever grade, is to be converted direct; it is hoped to keep the grade at 16 per cent. Direct treatment eliminates the regrading furnace and permits the handling of an increased quantity of green ore, all tending to reduce costs.

Electrostatic Fume Precipitation.[2]—In the paper of O. H. Eschholz, and in the discussion that follows, two methods of current application to electrostatic precipitation are in question. These are System A, where individual motor-generator rectifier sets are employed, and System B, where the current is taken from some power-plant main and rectified for precipitating. System A has been heretofore most largely used, since it was felt that it was more reliable than a current taken from a power-line that would be subject to voltage fluctuations, or where the power-company might fear trouble from such high-voltage installations. On the other hand, the power-line current has an efficiency of 86 per cent. as compared with 76 per cent. in the case of System A, and is cheaper to install.

We may note that at Tooele, Utah, alternating current from the smelter industrial-main is now used to supply power for the transformer-rectifier-treater sets. At Anaconda the company will employ thirteen motor-generator sets of 75 k.v.a., and after investigating the merits of both systems, they found but little difference in the estimates of costs. They anticipate better operating conditions and less liability of interruption in using System A. They are, however, putting in one unit according to System B for purposes of comparison.

[1] *Eng. Min. Jour.*, **106**, 989.
[2] *Bull. Am. Inst. Min. Eng.*, **140**, 1293; **142**, 1553; **143**, 1654; **144**, 5775; *Trans*, **60**, 243; MINERAL INDUSTRY, **26**, 191 (1917).

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For the good precipitation of the dust a certain percentage of moisture in the gases is necessary. This is brought about by spraying the gas current with a fine mist of water. The improvement is quite noticeable when the relative humidity is increased to 30 to 50 per cent. The deposited coating becomes moister in consequence, even to the condition of mud if the relative humidity rises to 70 or 80 per cent. Practice indicates that 42-per cent. relative humidity gives the best results.

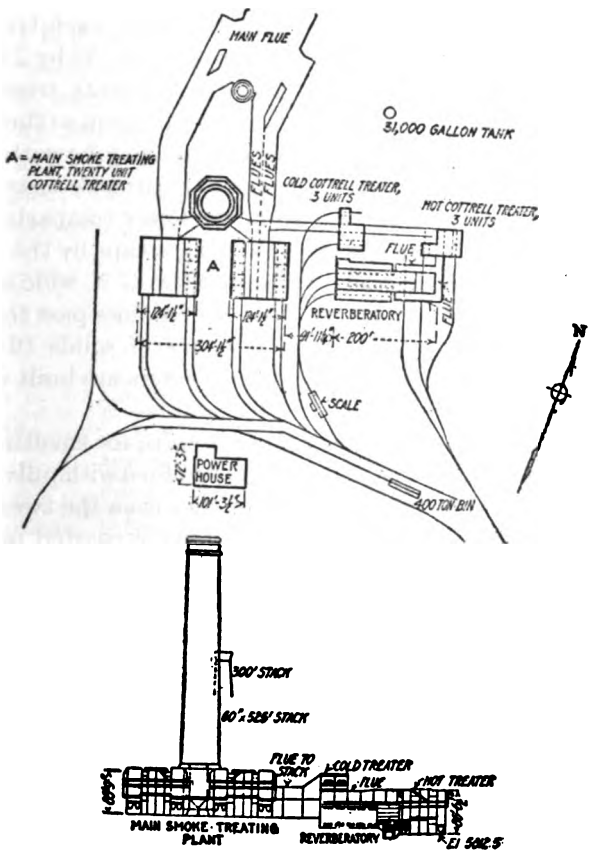

FIG. 3.—Plan and elevation of new stack at Washoe Works.

Smoke-treatment Plant of the Washoe Reduction Works.[1]—This installation at Anaconda, costing some $2,000,000, was put in for treating a volume of 3,000,000 cu. ft. per min. of the escaping gases of the reduction works, plus 1,000,000 cu. ft. additional of cooling air. Much of the flue dust, also the arsenic fume, are removed, and the gases thus freed are

[1] *Min. Sci. Press*, 116, 895; 118, 28.

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discharged at the high level of 1039 ft. above the level of the floor of the reverberatories, the base of the stack being on a hill 454 ft. higher than the furnaces.

Referring to Fig. 3, the main flue, which formerly terminated at the 300-ft. stack, branches with one branch on each side of this stack, and each flue divides into four compartments, continuing past the new main stack 585 ft. high by 60 ft. inside diameter. This stack is 225 ft. beyond the smaller one. At A, in the plan, is to be seen, on either side of the branch flues, five treater-units 20½ by 26 ft. inside, each treater of the box type, containing a series of corrugated iron plates, 24 by 21 ft., placed in parallel and hung 12 in. apart.[1] There are twenty treater-units in all, and, as noticed in the plan, tracks run beneath them so that when any one is shut off its accumulated precipitated dust may be withdrawn into cars for transfer to either of the reverberatory furnaces nearby.

The flue-gases enter the treaters from the lower compartment of the branch flues, and passing upward through them, escape by the upper compartment, and so to the main stack. The flues are 37 ft. wide at the treaters, and are built of steel and hollow tile. These flues pass the 3,000,000 cu. ft. of furnace-gases, which carry 280 tons of solids (flue-dust) in 24 hours. Of this 240 tons is caught. The treaters are built of steel and hollow tile.

The reverberatory furnaces, each 20 by 100 ft., for smelting the dust, are in a steel building 68 by 154 feet. These are fired with pulverized coal. The daily charges will include 240 tons of dust from the twenty treater-units, 45 tons of hot-treater dust and 155 tons of roasted ore, flux and other material, a total of 440 tons, using an amount of fuel calculated at 14 per cent.

The daily output is estimated at 50 tons of matte and 200 tons of slag. The furnace-gases from the reverberatory, containing dust and the arsenic volatilized from the furnace charge, pass through a flue, 33½ by 11½ ft. inside dimensions, to the hot-treater, where about 45 tons of dust is deposited daily. The hot-treater, as shown on the plan, consists of three units each 13 ft. 2½ in. by 23 ft. 6 in. inside. The escaping gas from the hot-treater, now freed from dust, passes by a flue 34 ft. 6 in. by 12 ft. 2½ in. inside to the three cold-treaters, each 13 ft. 2½ in. by 23 ft. 6 in. inside dimensions. Cold air is here introduced, which mixing with the gases causes the arsenic to condense out in visible flakes. It is these flakes that are precipitated in the cold-treaters, and are sufficiently pure after collecting to be sent to market. The daily recovery is estimated at 35 tons of arsenious oxide 92 to 95 per cent. pure in 24 hours. Any gas

[1] Between the plates are hung chains 12 in. apart. These are charged at about 75,000 volts, direct current. Electric power for the treaters is furnished by sixteen 75-kw. single-phase generators. Rectifiers, 48 in. in diameter, change the alternating into direct current to go to the chains.

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from the hot-treater not going to the cold ones passes away by a long flue to the nearer main branch-flue, and so through the main treaters again. Finally the gas from the cold-treaters, now containing some 15 per cent. of the original dust, will pass through another flue 20 ft. by 12½ ft. to the upper flue that leads to the 60-ft. stack.

The stack, 585 ft. high by 60 ft. inside diameter, was built in 142 days. It has an octagonal base 85 ft. high, above which it is circular. The thickness of the walls varies from 60 to 22½ inches. The chimney-blocks or bricks vary in length from 4 to 10½ in. by 6½ in. wide by 4⅝ in. thick. They are moulded from slime-flotation tailing mixed with sand in brick-machines and burned in brick-kilns. They are laid in a mortar of cement, fire-clay and sand. The chimney caps are of terracotta bricks, having interlocking joints. The computed cost of the stack is $400,000.

Metallurgical Chimneys or Stacks.—The table below is taken from a well-illustrated article on "Tall Chimneys in Metallurgical Plants."[1]

Situation.	Works.	Material.	Height, Feet.	Inside Diam. at Top, Feet.
Anaconda, Mont.	Anaconda Copper Mining Co.	Perforated radial brick	585.0	60.0
Tacoma, Wash.	Tacoma Smelting Co.	Paving brick	573.0	23.9
Saganoseki, Japan	.....	Reinforced concrete	570.0	26.2
Great Falls, Mont.	Anaconda Copper Mining Co.	Perforated radial brick	506.0	50.0
Murray, Utah	American S. & R. Co.	Perforated radial brick	450.0	20.0
Clarkdale, Ariz.	United Verde Ext. Mining Co.	Perforated radial brick	425.0	30.0
Clarkdale, Ariz.	United Verde Copper Co.	Steel	400.1	30.0
East Helena, Mont.	American S. & R. Co.	Perforated radial brick	400.0	16.0
El Paso, Texas	El Paso Smelting Works	Perforated radial brick	400.0	30.0
Collinsville, Ill.	St. Louis S. & R. Co.	Reinforced hollow tile	375.0	16.0
Bayonne, N. J.	Orford Copper Co.	Perforated radial brick	365.0	10.0
Port Colborne, Ont.	International Nickel Co.	Reinforced concrete	350.0	12.0
Anaconda, Mont.	Anaconda Copper Mining Co.	Brick	300.0	30.0
Blackwell, Okla.	Bartelsville Zinc Co.	Reinforced concrete	307.0	12.0
Tacoma, Wash.	Tacoma Smelting Co.	Reinforced concrete	300.0	18.0
El Paso, Tex.	El Paso Smelting Works	Reinforced concrete	300.0	16.0

Under the heading "Smoke-treatment Plant at the Washoe Reduction Works," we give particulars of the stack at Anaconda. It discharges 1039 ft. above the level of the reverberatory building floor. The Tacoma stack of paving brick, built by the Alphons Custodis Chimney Construction Co., stands on a concrete base 30 ft. deep. The brick shell varies from 5 ft. 1 in. thick at the base to 13½ in. just below the bell at the top. Its 4-in. sectional fire brick lining is separated from the shell by a 2-in. air space. Over 2½ million bricks were used in its construction, and its weight on the foundation is 12,000 tons. The stack stands on a ridge 150 ft. high, making the height 725 ft. above the adjacent sea-level. The smaller 300-ft. Tacoma stack, built by the Weber Chimney Co. of Chicago, cost $30,000, and was built on a reinforced-concrete base 39½

[1] *Eng. Min. Jour.*, 106, 168.

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ft. square by 6½ ft. thick, made of a 1 :3 :5 mix with stone not over 2-in. size. The shell was but 9 in. thick, to a height of 90 ft., 7 in. thick above, the lower 90 ft. having an inner lining of 4-in. brick with a 4-in. air space. The calculated maximum compression was 600 lb. per square inch and the tension of the steel reinforcing rods was 21,000 lb. per square inch for a wind velocity of 100 miles per hour. The horizontal reinforcing was of 1¼-in. tee bars. At Blackwell, Okla., these bars are ½-in. rounds, spaced at 14-in. centers, but wound spirally on the stack. The Saganosaki stack, the highest reinforced-concrete stack in the world, is built on a hill 430 ft. above the sea, making its top just 1000 ft. above sea-level. This stack, also built by the Weber Chimney Co., cost with appurtenances $250,000. It has a foundation 95 ft. in diameter. The shell thickness is 29½ in. at the base, tapering to 7 in. at the top; the maximum compression of the concrete is 550 lb. per square inch for a mix of 1:2½:4. The Clarkdale stack of the United Verde Copper Co. of steel, 30 ft. diameter, and built by the Chicago Bridge and Iron Works, is designed to handle 2,000,000 cu. ft. of gas per minute. The 16-ft. stack at El Paso, Tex., has a Wislicenus top, made by inserting rows of 2-in. pipe in the concrete for about 50 ft. from the chimney-cap, giving a peculiar perforated effect, and being intended to serve as a dissipator for the rising smoke. It was found to reduce the draft so much that the openings were afterward closed. There are twin stacks at Port Colborne, built by the General Concrete Construction Co., New York, the highest reinforced-concrete stack in North America. They take the gases from four flues, each 7 by 20 ft. section. The shell is 51½ in. thick at the bottom. The vertical reinforcing is of ¾-in. twisted bars, the horizontal of ¼-in. wire mesh laced triangularly and wired to the vertical rods. The mix is 1:2½:4, prepared in a batch mixer and poured in adjustable steel forms.

Smelters

Copperhill Smelter.[1]—At this plant of the Tennessee Copper Co. small blast furnaces are preferred for the better regulation of the grade of the fumes, which for the acid plant of the company should run 6 to 7 per cent. SO_2. By semipyritic smelting the plant treats 1200 tons daily of crude coarse ore of the average composition Cu, 1.6 per cent.; S, 25; Fe, 35; SiO_2, 18 to 20 per cent., using 6 per cent. coke. There is a closed top, and a slight plenum is carried, so that there shall be no air drawn in to dilute the fumes. The first matte runs 8 to 12 per cent., and this, concentrated with silicious ore, is raised to 22½ per cent. copper.

[1] *Eng. Min. Jour.*, **106**, 138.

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The Miami, Ariz., Smelter of the International Smelting Co.[1]—For sampling the wet and sticky flotation concentrates there smelted, a post-hole digger is used, this making in the material a cylindrical hole of about 4 in. in diameter. The Cottrell plant above the roasters (or dryers) works well, no escaping dust being visible. The calcines are withdrawn from the roaster calcine-hoppers into cars having sliding collars to make close connection to the hopper spouts. The car has a special pipe-connection for the return of the gases and light dust, generated in drawing off the calcines. Thus, no dust escapes during the transfer. At the reverberatory furnaces the charge-slides also have packed rod-handles to prevent escape of dust. The reverberatory slag contains Cu, 0.82 per cent. (on a 50-per cent. matte); SiO_2, 41.8; Al_2O_3, 13.3; FeO, 32.8; CaO, 7; S, 0.42 per cent.; Ag, 0.26 oz. per ton. The furnace-charge carries but 0.71 oz. of silver and 0.008 oz. of gold per ton. The ratio of oil to solid charge is 0.77 bbl. per ton. At the converters are produced ingots containing 99.32 per cent. copper with 2.82 oz. of silver and 0.039 oz. of gold per ton, a product too low in precious metals for electrolytic refining.

United Verde Extension Smelter.[2]—This works, designed by A. G. McGregor, is located in the Verde River Valley, seven miles from Jerome. It is to have a capacity of 1000 tons daily to produce a 38- to 40-per cent. matte, and will cost, as estimated, $2,225,000, or double the cost of five years ago. This is due in part to higher wages, in part to lower efficiency under conditions where labor feels quite independent, where steel costs twice as much, and other supplies even 2½ times as much as in 1914. The ore is silicious enough to need for fluxing a slight addition of limestone. This can be obtained close by. At present, for treatment at smelters at Bisbee, Humboldt, Douglas and Globe, the ore is sent to the railroad from the mine by a Leschem tram-line, 4600 ft. long.

Referring to the general plan, Fig. 4, the converter-aisle or building, lying axially east and west, is 58 ft. wide by 348 ft. long and on its north side are ranged the casting furnace, the converters and the skull-breaker. South comes the reverberatory-furnace building, 132 by 132 ft., separated by a space of 37 ft. from the blast-furnace building, 58 by 95 feet.

Within the reverberatory building is a furnace, 25 by 120 ft. hearth dimensions, with space for another. South of the reverberatory building is the boiler-house, 60 by 136 ft., containing three 713-hp. waste-heat boilers, each with its own flue to the main flue. In the figure a rectangle in the blast-furnace building, lying axially east and west, represents the blast furnace, and shows at one end of it the round-ended settlers. Leading from it is a bent channel, the matte launder. The blast furnace

[1] *Eng. Min. Jour.*, **106**, 143; MINERAL INDUSTRY, **23**, 230 (1914); **24**, 222 (1915); **25**, 240 (1916); **26**, 183 (1917).
[2] *Min. Sci. Press*, **116**, 476; *Eng. Min. Jour.*, **106**, 689; MINERAL INDUSTRY, **22**, 232 (1913).

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has two goose-neck down-takes (not shown in Fig. 5), leading south to a blast-furnace dust-chamber, 40 by 144 ft., provided with baffled plates for distributing the gas current. It again delivers near the end of the main flue. The blast-furnace flue has hoppers, whence the dust can be drawn

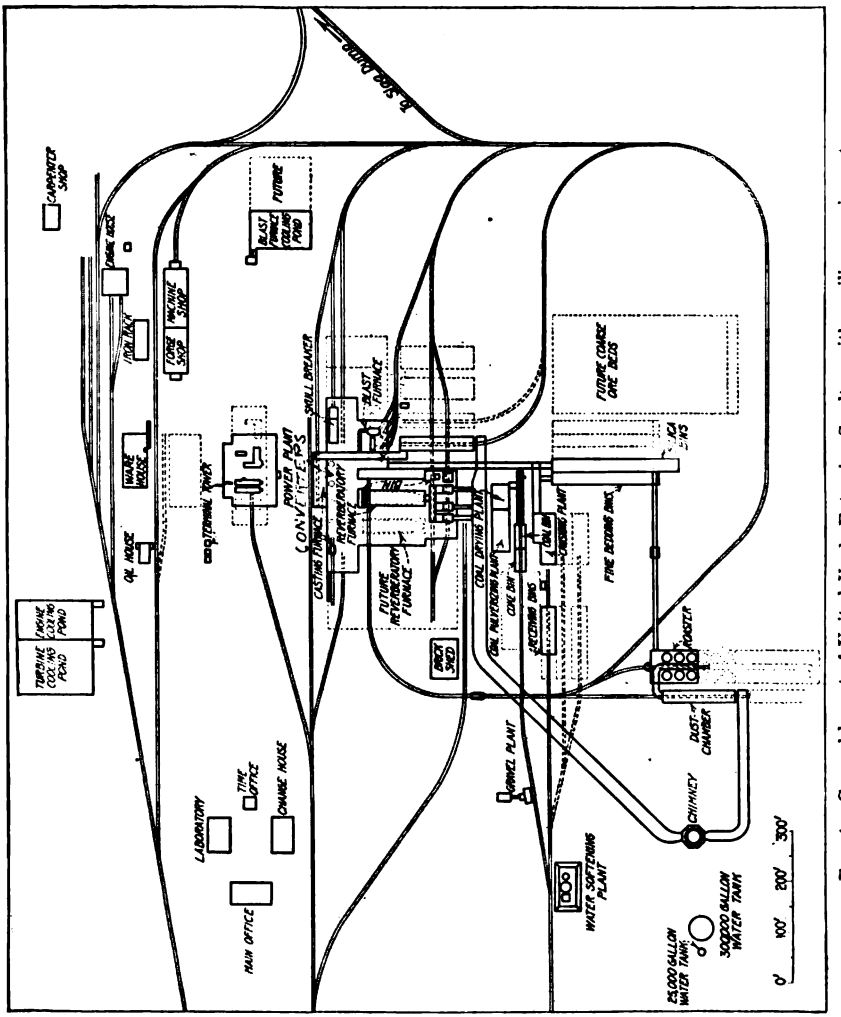

FIG. 4.—General layout of United Verde Extension Smelter, with auxiliary equipment.

off into cars set beneath. Against the north side of the converter aisle is shown the balloon-flue for the converter, leading high overhead so as to clear the traveling crane of the converter aisle. This flue discharges into the blast-furnace dust-chamber. At the converter is handled blast-

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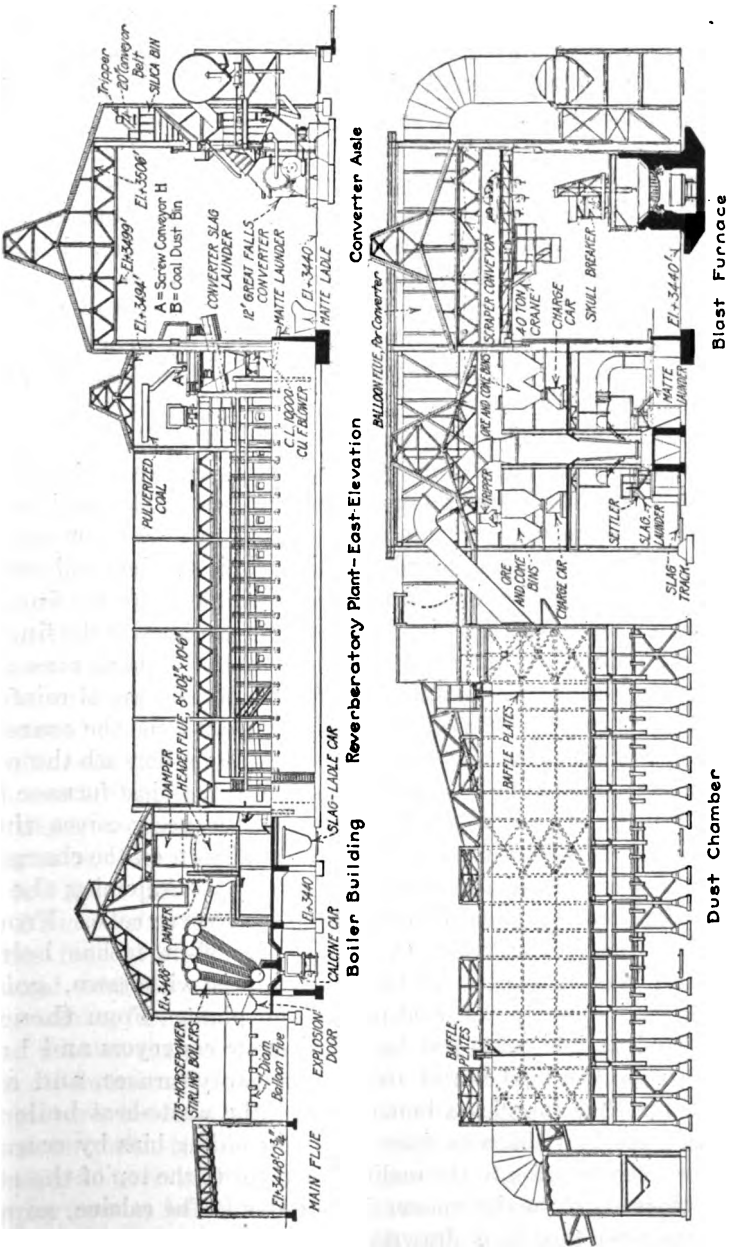

FIG. 5.—Section through smelter of United Verde Extension Mining Co.

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furnace and converter matte, ladle-skulls, converter slag and copper, by means of the 40-ton electric traveling crane with its two auxiliary hoists. The casting furnace is to have a straight-line casting machine. There are three 12-ft. Great-Falls-type converters, electrically driven. The sectional elevation, Fig. 5, shows the overhead silica-bins with spouts for delivery of the crushed ore directly to the converters. The brick main-flue, 20 by 25 ft. and 976.5 ft. long, leads to a stack 30 ft. in diameter by 425 ft. high. This stands on a hill behind the plant, its base 110 ft. higher than the main-building floor. Delivered at this high level of 535 ft. the smoke can do little damage to vegetation. In a roaster building, 64 by 94½ ft., are six Wedge six-hearth roasters, 21½ ft. in diameter. From these a flue leads to the roaster dust-chamber of 1000 sq. ft. area by 144 ft. long, and thence through a flue 16 by 16 ft. by 360 ft. long to the main stack.

Consider now the delivery of materials to the plant. High-level tracks, branching at the water-softening plant, lead over the receiving bins of 1500 tons, and over the coke and coal-bins of 300 and 600 tons respectively. From the steel ore-bins the ore is withdrawn upon a 30-in. conveying belt to the crushing plant, where it is crushed and sampled. Within the building a secondary unit is installed to sample the fines separately. After sampling, a 24-in. belt conveys the fines to the fines bedding bin adjoining. At the south end of the coarse bedding bins are the silica bedding bins, marked "silica bins." These bins are of reinforced-concrete construction, the fines bins holding 5000 tons, the coarse bins 4450 tons, while the silica bins hold 850 tons. From beneath the coarse-ore bins a 30-in. incline belt delivers the ore into the blast-furnace building. A 24-in. conveyor on each side of the furnace receives the ore, dropping it into feed-bins from which it is withdrawn on the charge-floor into the furnace charge-cars to the blast furnace. Adjoining the coke-bins is a coke-storage space, 75 by 150 ft., for reserve coke. From the coke-pockets the fuel is taken by belt to the 30-in. incline belt that supplies the blast furnace. As for coal, this is withdrawn, going to the coal-drying, then to the coal-pulverizing plant. From thence the dry powdered coal is conveyed by spiral-screw conveyors and bucket-elevators to an overhead bin at the reverberatory furnace, and a little to a small bin that supplies a boiler next to the waste-heat boilers.

Roasting ore is withdrawn from the fine-bedding bins by conveying belt, this delivering again to the incline-conveyor to the top of the roaster building, there to go to the roaster feed-chutes. The calcine, as well as the dust-chamber dust is is drawn off into tight lorries or cars, and is delivered by level tracks over the reverberatory furnaces to the furnace feed-hoppers.

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Arrangements for expansion are indicated by the dotted-in lines in Fig. 4.

The power plant, at present 104 by 144 ft., has 18,000-cu. ft. blowing engines for converter air, one Root direct-connected 400-cu. ft. blower for the blast-furnace air, and a 200-kw. motor-generator set for direct current for the plant. Water is obtained from wells 100 ft. deep, and is pumped to a 300,000-gal. concrete tank on a hill above the works. A water-softening plant nearby is used to reduce the hardness of this water for use at the boilers. One notes that the engine spray cooling pond is separate from the turbine cooling pond, and the blast-furnace cooling pond is in another place.

Hayden Smelter.[1]—This plant of the American Smelting & Refining Co., built in 1912, and then a two-furnace plant, with two Pierce-Smith converters, has now been increased by four reverberatories, and there has also been added one Pierce-Smith converter, 13 by 30 ft., and one 12-ft. upright converter. The converter flue, 18 by 19½ ft. in section, has been carried to a stack 16 ft. in diameter by 250 ft. high. With these additions the works has a capacity of 2000 tons daily, and an output of 10,000,000 lb. of copper per month.

The two newer reverberatories are heavily ironed to permit of hopper- or manger-charging at the sides. To this end the heavy H-beam buckstaves are spaced at 9-ft. intervals, and the thrust of the arch is taken by horizontal girders placed at its spring, thus leaving room for rectangular arched openings for the insertion of the hoppers. These latter are kept full of ore, to be pushed into the furnace as needed. The horizontal girders are broken at the expansion joints so that any section, if it becomes distorted, may be adjusted independently of the rest of the roof. The furnaces have been rearranged for powdered-coal firing, to supply which a 300-ton pulverizing plant has been installed.

El Paso Smelter.[2]—The copper department contains twelve Wedge roasters, four blast furnaces, four reverberatories, two Pierce-Smith horizontal and one Great Falls vertical converter; also two tilting hearth refining furnaces.

The roaster charge consists of 5 parts Chino table concentrates and 1 part oil-flotation concentrate. This latter, due to its contained oil and moisture, tends to agglomerate, some balls being as much as 4 in. in diameter, with the outside roasted, the interior raw. This charge, containing an average of 10 per cent. water, only completes its drying on the upper roaster hearth. The sulphur in the feed amounts to 14 per cent. and is roasted down to 8 per cent.; hence it issues quite hot from the lower hearths (550 to 650° C.). For these two reasons the last four

[1] *Met. Chem. Eng.*, **13**, 8; MINERAL INDUSTRY, **22**, 226 (1913).
[2] *Min. Sci. Press*, **116**, 711; *Eng. Min. Jour.*, **106**, 139.

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roasters have seven hearths in place of the five hearths of the first four; this is to insure more effective roasting. It is to be noted that the speed of the roaster arms can be varied at the will of the operator from one revolution in 21 sec. to one in 59 sec. by means of a resistance-coil regulator for the electric drive. Auxiliary heat is applied with three or four oil-burners on the first and third hearths. The table-concentrates have much contained magnetite, the Fe_3O_4 being in some of it as much as 48 per cent. The output per roaster is high, being 155 to 175 tons per day.

The blast furnaces, 144 by 44 in., are of interest, due to the method of dropping charges from overhead inclined-bottom charge-hoppers set on each side of the closed top. A man, standing on the charge-floor, can raise the charge-doors for inspection of the surface of the charge and for proper trimming, a procedure that eliminates one of the objections to automatic charging. The slag-spout for open-breast flow is a substantial one of ½-in. copper plate, 8 in. wide by 18 in. deep, having its front a nose or rather a dam of cast-copper of 98.5 per cent. copper and 1.5 per cent. tin. When running a 45-per cent. matte the spout endures, but the nose cuts out in six to eight months. The blast-furnace slag has an average content of 37 per cent. SiO_2, 38 FeO and 11 CaO and, due to running the present-grade matte, 0.46 per cent. Cu.

Of the reverberatory furnaces, the first two are 104 by 19 ft. in hearth area, the third 118 by 25 ft., and the newest one 130 by 28 ft., this being the widest thus far built, due to the method of side or bank-charging at the wall. True, some charge is dropped at three central hoppers, but wall-corrosion is prevented by maintaining the ore-bank, piled high along the walls. Increasing the furnace width gives greater melting area and the walls are more retired from the cutting flame. For such dimensions heavy buckstaves of 21-in. I-beams are used; at the ends box-beams take the expanding pressure of the roof, even though transverse expansion joints are provided. The matte is tapped at 30 ft. from the fire-end, the slag is skimmed or actually run off every 1½ to 2 hr., though continuous flow is necessary under the large tonnage now in use. The normal output for the 118-ft. furnace has been 450 tons daily, but this has been increased to 675 tons with an oil consumption of 0.72 bbl. per ton, and, with more favorable ore, even this will be increased.

This striking gain has been brought about by localizing the smelting zone, that is by so regulating the oil and air-supply as to confine the flame to the first 50 or 60 ft. of the furnace, and limiting the charging to the first 60 to 70 ft., leaving the remaining 60 or 50 ft. as a greater zone for settling. The temperature at the front is still high enough (1060 to 1260° C.) to maintain the slag properly melted. The slag carries say 38 per cent. SiO_2, 31 Fe (as FeO, and Fe_3O_4), and 0.33 per cent. Cu when

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smelting a 30-per cent. matte. It is low in other bases and viscid, due to the presence of the magnetite.[1] By increasing the silica and the furnace temperature the magnetite is reduced by the silica and the slag improves. But with much higher temperature softening and injury to the roof results.

The Pierce-Smith converters have a shell 13 ft. in diameter by 30 ft. long, carried by two riding-rings revolving upon self-adjusting rollers. The brick sole or bottom is raised to within 2 ft. of the tuyères by a sheet-steel false bottom. The basic-brick lining at the ends is 32½ in., at the tuyères 18 in., at the front side 13 in. thick. In operation, the bath is 40 to 60 in. deep, so that its surface is 10 ft. 5 in. wide by 24 ft. 7 in. long. This surface rises to within about 2 ft. of the orifice where enters the Garr silica gun by which silicious ore is fed to the charge as needed. Ore, crushed to 1½-in. size, is fed in required quantity from an ore-hopper into the injecting tube of the gun, where it is blown by an air-blast into the converter. Similar converters 13 by 30 ft. and using the Garr silica gun have been installed at two other plants of the American Smelting & Refining Co., viz., at Tacoma and at Garfield. At the latter plant 15,300 tons of copper was produced in one campaign, or 103 tons per day. The only repairs needed at the end of the campaign were in the vicinity of the tuyères. The charge, mainly 30-per cent. reverberatory matte, would weigh 225 tons thus treated. An initial charge is of four ladles-full, or 64 tons, then every 50 minutes one or two more ladles, the converter being skimmed before fresh additions of matte. Advantage is taken of the skimming period to clean the tuyères, stack, etc.; at the same time the brick, plastic under the intense heat, has a chance to harden, thus prolonging its life.

A record of one of these basic-lined converters was 318 days actual running time, with a production of 225,530 tons of blister copper or 70 tons daily, equivalent to 225 tons of matte. The repairs needed have been at 3 to 4 ft. above the slag-line and at the converter mouth.

There are 41 tuyères 1¾ in. in diameter, the centers at an estimated depth of 14 in. below the surface of the bath in blowing position. The blast-pressure, under this head, is 13.5 to 14 lb., and 170,000 to 200,000 cu. ft. of air is used per ton of copper produced. The blast is supplied by two Nordberg blowing-engines, respectively of 18,000 and 12,000 cu. ft. per min. capacity and by one turbo-blower of 30,000 cubic feet. The turbine of the latter is driven by exhaust steam supplemented, as needed, by live steam at 140-lb. pressure, and runs at 3350 to 3650 r.p.m. at 2000 brake horsepower. The converters are driven by a 75-hp. electric motor,

[1] The magnetite in the Chino table concentrates is now largely removed by the use of magnetic separators.

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a pinion on its driving shaft meshing into the spur shrouding-gear attached next to one of two riding-rings. The converter hood fits closely against the converter mouth. The converter smoke is drawn through a balloon-flue of 250 sq. ft. cross-section and 300 ft. long to a stack of 16 ft. inside diameter by 300 ft. high, the gases entering the stack at 150° C.

The molten blister copper from the converter is transferred by ladle to one of a pair of 145-ton tilting furnaces, lined with magnesia brick, 8 by 30 ft. inside. The charging spout and door are set centrally just above the hearth, the pouring spout opposite and slightly lower. The charge is poled through an end door, using green quaking-asp poles 30 ft. long, and using per month nearly 400 poles for the 4500 tons of copper refined by the two furnaces. In moulding, the copper is poured from the furnace into a cement-lined hydraulically operated pouring-spoon, and thence into the moulds of the Walker casting-machine. The anode moulds are of copper, cast on the spot, each mould having a cast-iron splash-plate cast into its bottom. The anodes are shipped to Baltimore, Md., for electrolytic refining. They contain 99.6 to 99.75 per cent. Cu and carry, when made from reverberatory matte yielded by Chino concentrates, Au 0.2 and Ag 12.0 oz. per ton, which at the present price of silver repays final electrolytic treatment. An alternative would be selective converting.

Ducktown, Tenn., Smelter.[1]—The plant of the Ducktown Sulphur, Copper and Iron Co. treats 500 tons daily in winter, 400 tons in summer, of an ore averaging Cu, 2.5 per cent.; Fe, 30; SiO_2, 26; S, 20; Al_2O_3, 2.5; CaO, 7 per cent., with traces of As, Te and Se. The first matte carries 13, the second 40 per cent. copper. Sulphur is here produced by drawing the blast-furnace fumes through incandescent coke, cooling, then using a Green fuel-economizer for heat exchange, then to treatment with Felt washers and a filter, giving a pure product of flowers of sulphur.

Calumet and Arizona Smelter.[2]—The details of this well-built modern plant at Douglas, Ariz., as described by Courtenay de Kalb, merit close study. The blast furnaces reduce the run-of-mine ore, reverberatory furnaces smelt flotation and table concentrates and flue-dust. The whole plant is compactly arranged, and yet with suitable provision for expansion. A sulphuric-acid plant annexed, yielding 177 tons of 50° B. acid daily, takes its sulphur fumes from five of the roasters. The ore, in part sulphide, in part oxidized, mainly from the company's mines at Warren, is some 2400 tons, averaging Cu 5.0 per cent., SiO_2 18, and S 28 per cent. The Shattuck mine contributes 500 tons of 5-per cent. copper ore, and for reverberatory fettling and converter flux silicious ore

[1] *Eng. Min. Jour.*, **106**, 138.
[2] *Min. Sci. Press*, **117**, 181, 302; MINERAL INDUSTRY, **23**, 242 (1914); **24**, 222 (1915); *Eng. Min. Jour.*, **106**, 141.

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from the Cornelia and 85-Mining Co. mines. Parallel to the present ore-bins a new line of bins has been added with a No. 8 gyratory crusher at the end of the line, where discharge goes to a new unit of the sampling mill. To insure uninterrupted operation in case of a breakdown or for repairs, the conveying belt system throughout the plant is in duplicate. The plant equipment now includes 24 roasters, two blast and four reverberatory furnaces, and six converters.

The roasters are of the Herreshoff type, 21 ft. 7½ in. in diameter of shell, electrically driven, and having six hearths. Five are operated closed, that is, their fumes go to the sulphuric-acid plant. The gases from the remaining nineteen, which are run open, pass to a dust-chamber 140 ft. long and 50 by 28½-ft. section, the walls built of hollow tile. The chamber is baffled in order to distribute evenly the current or draft. A steel stack, 20 ft. in diameter by 279 ft. high, then takes the fumes. The sulphide ore for the roasters, crushed normally to ½ in. by Symons disc crushers, contains 29 per cent. sulphur. It is roasted to 10 per cent. sulphur. The daily capacity per furnace is 90 tons for the open and 70 tons for the closed ones, though the open furnaces can be driven to 125 tons daily. On an average daily output of 96.4 tons for the open furnaces there is yielded 80.5 tons of calcine and dust, 70.1 per cent. of the sulphur being volatilized and 2.64 per cent. of flue-dust recovered. Typical analyses are as follows:

ROASTING-FURNACE MATERIALS

	Charge, Per Cent.	Calcine, Per Cent.	Dust, Per Cent.
Silica	16.6	18.1	16.5
Alumina	2.9	3.5	5.6
Iron (Fe)	31.7	38.2	28.7
Lime	1.6	1.9	2.3
Sulphur	29.6	9.9	10.7
Copper	4.67	6.12	6.54

Each of the two blast furnaces, 40 ft. long by 48 in. wide, described also in MINERAL INDUSTRY, **25,** 235 (1916), puts through an average of 996 tons of charge daily, containing 10.3 per cent. moisture, the coke being 12.7 per cent. and the flue-dust produced 3.8 per cent. of the charge. Some 58 per cent. of the sulphur is volatilized. Following are analyses of the furnace materials:

BLAST-FURNACE PRODUCTS

	Charge Average, Per Cent.	Slag Average, Per Cent.	Matte Average, Per Cent.	Flue-dust Average, Per Cent.
Silica	22.2	35.3	....	20.9
Alumina	5.3	9.4	....	8.0
Iron (Fe)	25.9	....	40.0	28.6
Iron (FeO)	....	37.8	....	....
Lime	5.9	9.0	....	2.4
Sulphur	13.1	....	25.3	9.1
Copper	5.29	0.41	28.81	5.0

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There are several novel features of construction in the reverberatory practice. There are three transverse expansion joints only, when cold 7 in. open at the crown of the arch, and less than 1 in. at the walls. The longitudinal 2-in. tie rods, six in all, each in three lengths for convenience in building, are carried on two transverse struts and tie the 21-in. I-beam buckstaves at the ends of the furnace. In operation, cold silicious ores are smelted, and just before skimming, some high-sulphide ore is used for cleaning the slag. It has also been proposed to superheat the front of the furnace by the use of auxiliary burners. The furnaces are smelting about 700 tons daily. Some 500 tons of molten reverberatory slag, containing 2.79 per cent. copper and 53.3 per cent. iron, is daily poured back into the reverberatory furnaces for recovery of the contained copper. As elsewhere pointed out this practice gives unsatisfactory results.

Below are analyses of the reverberatory products.

REVERBERATORY PRODUCTS

	Solid Charge.		Slag, Including Converter Slag.		Matte.	
	1 Per Cent.	2 Per Cent.	1 Per Cent.	2 Per Cent.	1 Per Cent.	2 Per Cent.
Silica	28.3	28.0	34.6	34.7	....	0.8
Alumina	4.1	4.0	6.0	5.8	....	....
Iron (Fe)	29.3	28.8	....	....	41.2	41.2
Iron (FeO)	....	....	47.5	47.9	....	....
Lime	3.0	3.0	3.7	3.8	....	....
Sulphur	8.5	8.8	....	....	26.1	25.7
Copper	5.16	5.4	0.39	0.40	25.03	25.3

The figures show a loss of 40 per cent. of the sulphur by volatilization, due perhaps to an oxidizing flame during the smelting operation. The oil used is given at 0.719 bbl., or allowing a credit of 0.313 bbl. for the steam, a net consumption of 0.416 bbl. per ton of charge.

Besides the six converter stands, there are two extra shells provided for prompt replacement. The 25-per cent. matte is blown to blister of 99.15 per cent. copper, and directly poured from 160-cu. ft. cast-steel ladles into ingots of 300 lb. each. The converter gases, 240,000 cu. ft. per min., show moderate stack-loss in dust, the dust containing Cu, 15.0 per cent.; Pb, 34; Zn, 9.5 per cent.; also 11.5 oz. of Ag and 0.086 oz. Au per ton. It is proposed to install a Cottrell treater to recover this.

Queenstown Smelter of the Mt. Lyell Mining & Railway Co.[1]—For the year ending Sept. 30, 1918, the smelter reduced 240,947 tons of ore, yielding 13,031,539 lb. of copper, 320,340 oz. of silver and 7042 oz. of gold. The flotation plant concentrated 29,703 tons of 2.95-per cent. ore,

[1] Company report to Sept. 30, 1918; *Min. Sci. Press*, 117,878.

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giving a recovery of 88.06 per cent. This concentrate is sintered for smelting.

Trail Smelter.[1]—The copper smelter at this plant of the Consolidated Mining & Smelting Co. includes two 35-ft. and two 25-ft. blast furnaces, and two 12-ft. Great-Falls-type converters. The copper refinery has at present a capacity of 20 tons of copper daily.

Humboldt Smelter.[2]—This plant of the Consolidated Arizona Smelting Co. yields 1,800,000 lb. of copper per month. It includes four Wedge roasters, one blast furnace, and one reverberatory furnace. About half the ore is from the company's own mines, the Bluebell and the De Soto, the balance being custom ores. The concentrating mill at Humboldt has a capacity of 500 tons daily, treating ores of 65 to 75 per cent. silica from the company's mines. The general mill produces a mixture of table and flotation concentrates to the amount of 125 tons daily, averaging Cu, 8.5 per cent.; insol., 20; Fe, 28; S, 31 per cent.; Ag, 3.2, and Au, 0.12 oz. per ton. This product, still retaining 15 per cent. moisture, is delivered from the Portland filter of the mill by belt-conveyors to either of two hopper-bottom storage-bins of 350 tons each. All direct-smelting ore, whether company or custom, is delivered by railroad cars into twelve receiving-bins of 2000 tons total capacity. The ore is withdrawn from these bins upon a 30-in. conveying belt to the sampling and crushing plant. Here it is coarse-crushed, sampled and screened through a trommel fitted with 1½-in. punched plates, the oversize then going to various blast-furnace bins for the different ores. The undersize is crushed in rolls to yield a product of ¾-in. size, and conveyed by belt to the reverberatory feed-bins. Storage bins are also provided for custom concentrates. The blast furnace, of 300 tons capacity, which takes the coarse ore of over 1½ in., is charged on alternate sides, using Anaconda-type charge-cars tilted by air-hoists. A charge consists of 10,000 lb. of ore, limestone and slag-skulls, with 11 per cent. coke. The air pressure is 26 oz.

The roaster plant contains four seven-hearth Wedge roasters, 22 ft. 6 in. in diameter and four Cottrell treater units. From the custom and company concentrates bins, the fine concentrate is withdrawn upon conveying belts for delivery to the top of the roaster building, where it is discharged by trippers into 125-ton feed-hoppers set above and feeding by belt-feed to the roasters. Notwithstanding that the concentrate bins are fitted with belt-feeders and have steep hoppers, it is necessary, due to the high moisture in the sticky material, to poke it down by hand. The roaster feed will average 10 per cent. copper and 26 per cent. sul-

[1] Annual Report, Minister of Mines of British Columbia; *Eng. Min. Jour.*, **106**, 792.
[2] *Ariz. Min. Jour.*, **2**, 17; *Min. Sci. Press*, Mar. 9, 1918; MINERAL INDUSTRY, **25**, 230 (1916); **26**, 180 (1917).

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phur; the calcine still retains 6 to 7 per cent. sulphur. Because of the high sulphur in the feed little or no fuel-oil is needed in roasting. From each roaster a 36-in. pipe leads to the bottom of each treater, there being one for each roaster, divided into two sections, so that either section can be cut out for cleaning. Each section contains 40 tubes, 12 in. in diameter by 16 ft. long. The axial discharge-electrode is a small chain for the 75,000-volt current. The treated smoke passes away by the 48-in. stack above. From the two treater hoppers the dust, after jarring it down, is withdrawn upon 10-in. horizontal screw-conveyors, these dropping their load by long pipes into the calcine hoppers. The two calcine hoppers, each of 36 tons, set at the center line of the building, are provided with four discharge openings. These correspond to four openings, provided with sleeves on the closed top of the calcine-car. The car is spotted beneath the hopper, the sleeves making a close joint, so that the calcine can be withdrawn without loss of dust.

The reverberatory, 19 by 100 ft., treats 250 to 300 tons of dry charge daily, 75 per cent. of it being calcines, the balance silica ore suited for fettling. Feeding is through hoppers along the sides. For fuel, California crude oil of 14° B. is used. There are two 350-hp. waste-heat boilers. They give power enough for the converter blowing-engine, but it is supplemented by hydro-electric power purchased from the Arizona Power Co.

Both blast and reverberatory furnaces yield a 35-per cent. matte, transferred by two 30-ton traveling cranes to three 7½- by 10-ft. horizontal converters, basic lined. These are, however, too small for the most satisfactory work.

In 1917[1] the plant possessed but a single roaster, and to put through the tonnage which the concentrator furnished, half the reverberatory charge had to be made up of coarse-crushed crude ore; also the blast-furnace charge carried 20 per cent. of fine concentrate. As a result, both furnaces carrying charges high in sulphur and low in copper produced much low-grade matte, which kept all three converters busy. But with the increase to four roasters with their Cottrell treaters the concentrate was all roasted, and was smelted together with some crude ore in the reverberatory, so that the blast furnace was running but part of the time. Next, the reverberatory was shut down and remodeled to conform to the new method of increasing capacity, and again brought into operation to an output of 500 tons daily, thus taking care of all the ores brought to the plant and enabling the shutting down of the blast furnaces. While they were still in operation, fluxing was done by addition of lime-rock, but this was supplanted by specular hematite ore containing Cu, 3.5 per cent.;

[1] *Eng. Min. Jour.*, **106**, 137.

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Fe, 48.8; S, 4.5; and insol., 11.8 per cent. There resulted an irony slag of about the same copper content as the former limy one. It is shown that in the first 6 months of 1918, with a monthly tonnage of 13,000 to 14,000 tons, costs have been decreased from $3.60 per ton in January and February to $2 at the end of June. The Cottrell units started the end of February, copper recovery then being 91 per cent., and by the end of June it had risen to 97 per cent. Again, in January and February, 1918, the production of fine copper was 1,800,000 lb. This increased to 2,225,000 in March, dropping to 2,000,000 or less in May and June.

Converting costs, nearly 1 ct. per pound of fine copper in January and February, had fallen to 0.64 ct. by May and June.

Copper and Copper Alloys

Automatic Copper-plating.[1]—When it is attempted to plate sheet-iron by immersing it in a bath of molten copper, the high temperature causes oxidation, both of the sheet and of the surface of the molten copper. However, by applying the plating metal to the sheet while both are cold, then melting the metal on the sheet, success may be attained. A plating mixture of copper oxide or finely divided copper, ground with Mexican crude oil having an asphaltic base of 14° to 16° B. is prepared, using 4 lb. of copper oxide, 4 lb. of finely precipitated copper and 1 gal. of the oil. The sheet is coated uniformly by means of inking or coating rolls, and this is exposed to the furnace temperature so as to produce a strongly adherent coating of copper upon the sheet, reduction of the copper oxide or of any oxide on the sheet being effected by the asphaltic base of the oil in the reducing atmosphere of the furnace. All these operations are done by an automatic sheet-feeding, coating, and plating machine.

Copper in Steel.[2]—Copper to the extent of 0.86 per cent. in medium-grade steel of 0.38 per cent. carbon produces superiority over low-carbon steel as respects tensile strength, yield point, hardness and ultimate strength, while its ductility and elongation is practically the same. In these respects it resembles nickel steel.

The Gassing of Copper.[3]—The detrimental effect of reducing gases upon hot copper is well known. If a strip of electrolytic copper containing an average content of 0.05 per cent. Cu_2O is heated in an electric furnace for 30 min. and exposed to hydrogen gas at full red heat (800° C.), the copper, after cooling, becomes so weak that it will not withstand bending. This action also takes place in presence of natural gas or carbon

[1] *Met. Ind.*, **17**, 18; U. S. Pat. Nos. 1197693, 1197694, 1197695; *Bull. Am. Inst. Min. Eng.*, **145**, 27; *Trans.*, **60**, 365.
[2] *Bull. Am. Inst. Min. Eng.*, Jan., 1918; *Met. Chem. Eng.*, **18**, 260; *Eng. Min. Jour.*, **105**, 371.
[3] *Bull. Am. Inst. Min. Eng.*, **142**, 1567; **145**, 103; *Trans.*, **60**, 322.

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monoxide, but not nearly to the same degree. After such treatment the copper becomes quite porous and contorted. The pores are considered to be due to the reduction of the copper oxide to the metallic state, that is, to 60 per cent. of its former volume. Such action begins at 400° C. and increases progressively to 800°. The physical change becomes the more marked the higher the percentage of copper oxide. Thus, when the copper contained 0.5 per cent. Cu_2O, the copper, after reduction by hydrogen, appeared swollen and shattered, as though due to the explosive action upon cooling of the occluded gas.

Boronic Copper.[1]—The American Boron Products Co., Reading, Pa., prepare boron-containing alloys for scavenging copper and aluminium bronzes. These are boronic copper made from electrolytic copper containing occluded boronic gases, and boronic aluminium. An addition of 1 to 2 per cent. of boronic copper to molten copper so cleans and toughens it that from it sound copper castings can be made, such as copper tuyères; also coins free from pores and proof against oxidation. In the same way boronic aluminium, added to aluminium bronze, deoxidizes it, giving it greater strength and density.

Acid-proof Copper Alloys.[2]—Dr. Ronald Ermann finds a nickel-copper alloy carrying 48 per cent. copper and 5 per cent. tungsten highly resistant to sulphuric and other acids, and at the same time mechanically strong. Its electrical resistance was higher than that of constantan. When the sulphuric acid is cold the alloy should be richer in copper and lower in tungsten and iron. For hot concentrated sulphuric acid he recommends a copper-nickel alloy of Cu, 43.65 per cent., W, 3.9 and Fe, 1.87 per cent. This alloy has a very high electrical resistance, can be easily machined, and has a tensile strength of 28 tons per square inch, which rises to 35 tons when the iron is increased to 3.9 per cent.

Brass Weakness.[3]—When brass-headed nails are driven home by a hammer which partly flattens them, minute fractures develop, due to the distortion of the metal and the change of the strong compact microscopic grains to larger weaker ones. Brasses may be divided into three grades, red, yellow and white. In the red grade yellow alpha crystals appear as the grade approaches 71 per cent. From 71 down to 64 per cent. Cu, the brass, when just solidifying, shows alpha and beta crystals, but when annealed at 400° C. the beta crystals become absorbed by the alpha crystals. Finally, the white brasses of 45 per cent. Cu or less are mostly composed of delta crystals. It is to development of this type of crystals, and to violent distortion by hammering, that the weakness above mentioned is due.

[1] *Eng. Min. Jour.*, **105**, 206; MINERAL INDUSTRY, **19**, 219 (1910); **25**, 249 (1916).
[2] *Met. Chem. Eng.*, **18**, 261; *Metal. u Erz.*, **14**, 201.
[3] *Met. Ind.*, **16**, 319; *Bull. Am. Inst. Min. Eng.*, **144**, 1726.

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Bronze Bearing Metals and Bell Metals.[1]—Due to the high price and scarcity of tin in 1918 the necessity of conserving it has been forcibly brought to the attention of consumers, and an effort has been made to reduce the percentage of tin in alloys or to substitute alloys not containing tin. The following table gives the composition of certain copper alloys in general use by the Pennsylvania R. R. Co. Phosphor bronze

	Copper.	Tin.	Lead.	Phosphorus.	Antimony.	Zinc.
Phosphor bronze, Spec. 32-C	79.70	10.00	9.50	0.80	....	....
Ex. B bronze, Spec. 141	76.75	8.00	15.00	0.25	....	....
Car-journal bronze (*a*)	71+	4+	13–20	....	....	.3–
Special high-lead bronze, Spec. 59	70.00	5.00	25.00	....	....	....
Bell metal	83⅓	16⅔	.....	....	....	....

(*a*) Sum of Cu, Pb, and Zn not less than 99.

is used for rod-bushings, main-rod brasses and cross-head shoes. Although a 73 copper, 7 tin, 20 lead alloy serves on light locomotives, yet the brasses of heavy ones are subject to severe impacts, and so the phosphor bronze of high compressive strength is needed. The lead in it gives a slight plasticity to the bearing and the rate of wear is less than when no lead is used. Ex. B bronze is cast for the backs of car bearings, these bearings then being babbitted for use. Car-journal bronze, however, is the principal alloy for these backs. Special high-lead bronze is used for locomotive driving box shells, which are not lined. Bell metal is used for making locomotive bells.

Structural Bronzes.[2]—Following is a table of some of these bronzes:

	Tensile Strength, Lb. per Sq. In.	Elastic Limit, Lb. per Sq. In.	Elongation in 2 In.
Government bronze, Cu, 88; Sn, 10; Zn, 2	38,860	12,250	25.2
Cu, 88; Sn, 8; Zn, 4	39,220	11,000	30.6
Aluminium bronze	71,000	25,000	21.0
Manganese bronze, U. S. N.	70,000	35,000	30.0
Naval brass (over 1 in. diam.)	54,000	25,000	40.0
Naval brass (less than ½ in. diam.)	60,000	27,000	35.0
Sillman bronze, Cu, 86; Al, 10; Fe, 4:			
Wrought	84,400	14,000	11.5
Cast	78,850	11,500	14.5
Alloy, Cu, 88; Sn, 5; Ni, 5; Zn, 2	40,680	13,050	31.8
Alloy, Cu, 89; Sn, 4; Ni, 4; Zn, 3	39,675	11,500	31.2

Aluminium Bronze and Phosphor Bronze.[3]—Bronze of the composition copper 90 per cent., aluminium 10 per cent., has double the tensile strength of the copper-tin bronzes; also it is superior in its resistance to shock, and in resistance to wear in some cases superior, in some equal, to the copper-tin alloy. It is consequently well suited to use in worm-gearing. The chief objection to aluminium-bronze is the difficulty of

[1] *Bull. Am. Inst. Min. Eng.*, **144**, 1729; *Trans.*, **60**, 162; MINERAL INDUSTRY, **15**, 246 (1906).
[2] *Bull. Am. Inst. Min. Eng.*, **144**, 1746; *Trans.*, **60**, 179.
[3] *Bull. Am. Inst. Min. Eng.*, **144**, 1738; *Trans.*, **60**, 171.

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securing good castings. On the other hand it possesses equally good properties, whether cast or rolled; it has great resistance to alternating stress, so that it greatly outlives even steel bolts subject to shocks.

Cupro-nickel Alloy.[1]—The cupro-nickel series form solid solutions. The particular alloy we discuss is that of 85 per cent. Cu and 15 Ni, electrolytic metals being used in making the alloy. Some 0.3 per cent. of manganese as manganese-copper is added to the melt as deoxidizer or scavenger, about 0.2 per cent. remaining in the alloy, which melts at 1150° C., the proper casting temperature being 1300° C. Since segregation occurs on solidification, the alloy must be annealed for two to three hours. When rolled, a reduction of 50 to 60 per cent. in area is allowed before again annealing. As compared with brass, cupro-nickel increases more slowly in tensile strength as its area is reduced; also elongation drops off more quickly with brass than with the copper-nickel alloy.

Silicon Bronze.[2]—This alloy containing copper, tin and silicon, owing to its high conductivity, has largely superseded other alloys for telegraph and telephone wires, and this due to its small silicon content.

Normal silicon bronze contains 5 per cent. of tin and traces of silicon, 0.25 to 0.5 per cent. being added in making the alloy, and serving as a scavenger or deoxidizer. Besides this the traces retained add to its hardness, compactness and tensile strength.

Cadmium in Brass.[3]—It has now been well established that when the cadmium in brass is less than 1 per cent. its presence is not a detriment. Such brass can still be used for deep draws or for spinning. Indeed there is getting to be a belief that cadmium in this small quantity is rather a benefit.

ELECTROLYTIC REFINING

The Design, Operation, and Costs of an Electrolytic Refinery.[4]—This report, compiled by the Canadian Munition Resources Commission, with the aid of R. W. Deacon, superintendent of the Chrome, N. J., refinery, gives valuable information on electrolytic refining, supplementing the data already given in MINERAL INDUSTRY, notably the articles by Titus Ulke,[5] Lawrence Addicks,[6] and Arthur Walker.[7] A detailed description is given of the probable cost of construction of a refinery to handle 50,000 tons of blister copper annually. The basis of cost estimate is defined and estimates made of initial and operating expenses, in connection with outlines of the proposed practice.

[1] *Met. Ind.*, **17**, 26; *Bull. Am. Inst. Min. Eng.*, **143**, 1697; **144**, 1783; *Trans.*, **60**, 373.
[2] *Met. Ind.*, **16**, 464.
[3] *Met. Ind.*, **16**, 370.
[4] S. E. McAllister, *Eng. Min. Jour.*, **106**, 337.
[5] MINERAL INDUSTRY, **6**, 238 (1897); **8**, 184 (1899); **10**, 217 (1901).
[6] MINERAL INDUSTRY, **15**, 301 (1906).
[7] MINERAL INDUSTRY, **17**, 324 (1908); **19**, 216 (1910).

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Punching Starting Sheets.[1]—The loops attached to the sheets have been heretofore automatically punched and fastened by two flaps, one above the other; the better way is to turn the punching die so that the flaps and slots are horizontal, thus making a stronger tie.

Lugless Copper Anode.[2]—F. L. Antisell has patented improved anode and cathode suspensions as shown in Fig. 6. Two types of anode suspension are shown. Such an anode can be cast thinner and smoother, and will give better contact than the lug-anode. The anodes and cathodes can be hung closer together and more true than heretofore, saving space and current and producing less scrap. Due to the shape of the lug, the

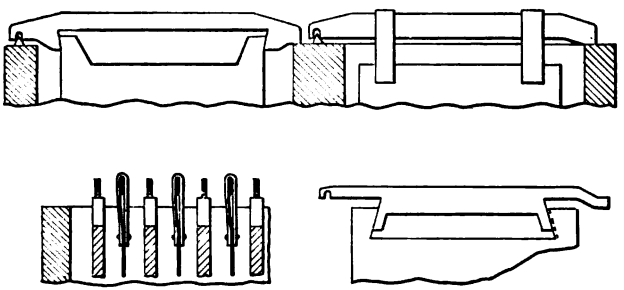

FIG. 6.—Details of lugless copper anode.

anode is closely pinched by the suspending bar, the lug is easily cast, and stands shipping with little damage. Contact-loss has been reduced from 10 per cent. to 2½ per cent.

Purity of Melted Cathodes.[3]—Cathode copper 99.98 per cent. and over in copper, when melted, becomes less pure, due to absorption of sulphur from copper sulphate left on the plates in the tank-house, and from the sulphur in the fuel used in the melting operation. Even well-washed cathodes still retain 0.002 to 0.004 per cent. sulphur.

When melted under a cover of coke breeze up to the end of the oxidizing period, the bath has taken up no sulphur; but toward the end of the poling period, samples taken showed some sulphur. This increased until at the end of the casting period as much as 0.0031 per cent. of sulphur was present. The final product would analyze 99.93 copper, with a conductivity of 100. By melting under a charcoal cover containing only 0.03 per cent. sulphur, a final product was produced of 99.966 copper, having a conductivity of 100.5. Due to the lower sulphur in the second charge, less oxygen was needed to bring the copper to pitch or to be retained by

[1] *Eng. Min. Jour.*, **106**, 1126.
[2] U. S. Patent, 1250757, *Eng. Min. Jour.*, **105**, 924.
[3] *Bull. Am. Inst., Min. Eng.*, **135**, 645; **145**, 95; *Trans.*, **60**, 307; *Eng. Min. Jour.*, **106**, 15.

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the metal, hence its improved quality. The reversible reaction expressing this is:

$$6Cu + SO_2 \rightleftarrows Cu_2S + 2Cu_2O;$$

that is, low sulphur results in a low oxygen absorption. G. H. Clamer points out that a high grade of copper would result from melting the cathodes in a neutral or reducing atmosphere in an electric furnace.

Operating Control in Electrolytic Refining.[1]—In order to maintain high ampere efficiency attention should be given to the following points: Freshly cleaned electrical contacts must be provided; the contacts should be oiled; the cathode starting sheets must be carefully hung; the anodes and cathodes should be placed equidistant and properly centered in the tank; and finally there must be detailed and systematic inspection, both by hand and with the voltmeter.

HYDROMETALLURGY OF COPPER

Ramon-Beskew Chloridizing Furnace.[2]—As used by the Virginia Smelting Co., Norfolk, Va., this furnace has five round hearths with a central vertical shaft and rabble-arms. The charge, ground to 10-mesh, is dried out and so pre-heated on the top hearth as to start the chloridizing reactions, then passes by gas-sealed openings to the next hearth and to lower hearths in succession. The gases from the top hearth go directly to the stack. Just sufficient air is admitted at the lower hearths to keep the reactions going, and the products of the reaction, chiefly hydrochloric and sulphuric acids, passing upward from hearth to hearth, are drawn off at the second one to the chloridizing tower, undiluted by the top-hearth gases. The furnace is square in plan, the walls thick to lessen heat losses, and in the corners are gas-flues from the different hearths.

The output of the furnace is 50 tons daily, using nearly 3 per cent. coal and yielding a calcine containing Cu, 2.5 to 3.1 per cent.; Fe, 50 to 55; and S, 3 per cent. After leaching this product, the tailings retain but 0.15 per cent. copper.

Comparison of Costs of Acid- vs. Ammonia-leaching.[3]—The figures following are for a plant of 200 tons daily capacity, 15 miles from a railroad, treating oxidized ore containing 2.3 per cent. copper. Hauling costs 20 cts. per ton-mile. Recovery is 87 per cent. or 8000 lb. of copper in each case.

For acid-leaching, 3 to 6 tons of water will be needed per ton of ore, especially if it is thoroughly washed for subsequent recovery of gold and silver by cyaniding. The apparatus should be lead-lined to resist the

[1] *Eng. Min. Jour.*, **106**, 95.
[2] MINERAL INDUSTRY, **25**, 252 (1916); private communication.
[3] Private communication.

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acid attack. The product made is a precipitate of 70 to 80 per cent. copper. The daily costs will be: Supplies: acid, 20,000 lb. at 1 ct., $200.00; scrap-iron, 10,000 lb. at ½ ct., $50.00; hauling, at $3.00 per ton, $45.00; total, $295.00. Labor cost, $75.00; renewals, $100.00; crushing to 10-mesh, $50.00. Grand total, $520.00, or $2.59 per ton.

For ammonia-leaching but little water will be needed, the loss being that entrained in the tailings. The solutions have no effect on the apparatus. The cost of labor is low; the precipitates are readily filtered and shoveled into cars. The daily costs will be: Supplies, 600 lb. of ammonia at 10 cts., $60.00; 13,500 lb. of oil at $2.00, $112.50; hauling 6.5 tons at $3.00, $19.50; total, $192.00; labor cost, $75.00; renewals, etc., $50.00. Grand total, $367.00, or $1.83 per ton. Ammonia-leaching has the advantage that in case of subsequent treatment of the tailings for the recovery of gold and silver by cyaniding, these are in good condition for such treatment. An ore containing limestone would consume much acid.

Heap leaching.[1]—The Phelps-Dodge Co. has a heap of low-grade copper ore at Bisbee, Ariz., and at Tyrone, N. M., an experimental heap of 20,000 tons; both are being treated by leaching. At the latter place it is planned to investigate the method exhaustively, and a large leaching plant has been designed. At Santa Rita, N. M., the Chino Co. is building a pile of 90,000 tons, now under treatment. From experiments thus far made, it is calculated that 40 per cent. of the copper is extracted the first year, 20 per cent. the second, and 15 per cent. the third year, making a total of 75 per cent. recovered. After that, it is thought extraction will be too slow to be profitable. Rio Tinto methods will be the basis of operation.[2]

At Bisbee, Ariz., the ground was prepared for a 10,000-ton heap by tightening the soil with clayey slimes, using the included creek bed as a main drain, laying 12 by 12-in. side drains to the main one, cribbing over and planking at the creek bed and side of the area, all to furnish a durable and water-tight bed. Low-grade ore, averaging Cu, 1.3 per cent.; SiO_2, 60.7; Fe, 10.5; CaO, 1.2; Al_2O_3, 12.1; S, 9.9 per cent., with Ag, 0.1202 oz. per ton, a partly oxidized silicious, aluminous ore, that had been stripped to expose higher-grade ore beneath, was utilized for the leaching heap, the expense of building the heap being 60 cts. per ton, which, at a 75-per cent. extraction, would figure about 3 cts. per lb. of copper recovered. This includes no outlay for the precipitating plant, since the main water-plant was to be utilized for the purpose. In operation it was found that the neutral exhausted solution from the precipita-

[1] *Eng. Min. Jour.*, **105**, 225; MINERAL INDUSTRY, **24**, 247 (1915); **25**, 252 (1916).
[2] MINERAL INDUSTRY, **12**, 112 (1903); **15**, 288 (1906); **17**, 278 (1908).

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tion launders, high in ferrous iron, needs a small addition of sulphuric acid, and by thus maintaining acidity, the ore does not disintegrate or slime so as to hinder leaching. Between successive leaches the ore-heap, of an average depth of 20 ft., is allowed to drain and dry, the air drawing up through the heap and oxidizing part of the iron to ferric form. This ferric-iron solution has the solvent action on copper oxide which is lacking when ferrous iron only is present.

The leaching plant at Tyrone (Burro Mountain), arranged for 40,000 tons of ore, has a flat site for the leaching heaps. The precipitation-launders are at a level 60 ft. higher, to which the drainage solution from the heaps is pumped. The ore to be treated is from an old ore-dump, partly oxidized, but still containing copper sulphides and carrying 2.71 per cent. copper. Geo. W. Young[1] points out that due to the heterogeneity of the heap, channeling may occur. The clayey zones will leach slowly, while through the coarser parts of the bed, the solution will run through too rapidly, also the lumps, after saturation, would remain inactive. Oxidation, he conceives, results from air carried down by the solutions. He points out the difficulties of avoiding seepage loss through leakage of the bed. Practically, a clay-tightened bed has been found to be cheap and reasonably tight.

R. T. Hancock[2] thinks it would be better to send the heap drainage at once to Pachuca tanks for aeration with the addition of sufficient acid, and return the solution, thus reinforced in ferric iron, to the heap, keeping up this cycle, until, after a preliminary circuit or two upon the heap, the solution is to be pumped to the precipitation launders in order to precipitate the copper.[3]

Tailings Leaching at the Wallaroo & Moonta Smeltery.[4]—The cementation treatment of the slime[5] is performed on two shifts daily at the Moonta property, where the tailing-heaps are leached in rotation during night shifts and week-ends. In the first six months of 1918, this leaching yielded 404 tons of precipitate of 68.81 per cent. copper. In the same period the Wallaroo mines produced 29,586 tons of 8.69-per cent. copper ore, and the Moonta mines 4396 tons carrying 13.91 per cent. copper.

Precipitation of Copper from Solutions with Coke Fines.[6]—Robert Slessor recommends the use of shallow precipitating troughs, filled with alternate layers of scrap-iron and coke breeze, preferably of pea size, the two forming a voltaic current. The iron is not consumed; the copper

[1] *Eng. Min. Jour.*, **105**, 338, 430.
[2] *Eng. Min. Jour.*, **105**, 882.
[3] We infer also that he proposes that lime-water should be treated by sulphur dioxide to acid reaction. After it has been circuited and heated to boiling a pyrosulphite salt cystallizes out, and this is to be used for precipitating from a copper solution a dirty reddish cupro-sulphate, which, on boiling, falls out as a brilliant vermillion granular precipitate.
[4] Company Report to June 30,1918, *Eng. Min. Jour.*, **106**, 779.
[5] MINERAL INDUSTRY, **24**, 246 (1915).
[6] *Eng. Min. Jour.*, **105**, 1089.

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deposits as a layer on the coke. The solution should be clear and free from slime. The copper-bearing coke can then be mixed with the ordinary blast-furnace charge for smelting.

Leaching Plant of the Utah Copper Co.[1]—Briefly, oxidized ore is leached with sulphuric acid, and the dissolved copper is precipitated on scrap-iron.

The ore is that of the oxidized capping stripped from the main mass of sulphide ore. It will average a content of 0.65 per cent. copper in oxidized form as malachite and azurite and contains 0.1 to 0.2 per cent. of sulphides as chalcopyrite and chalcocite. This ore is brought to the crushing mill of the leaching plant in 64-ton railroad cars, where it is crushed in Gates crushers followed by rolls. The crushed product shows about 10 per cent. coarser than ½-in. size, more than 40 per cent. coarser than 3-mesh, and only 20 per cent. finer than 20-mesh—certainly an easily leached material.

The coarser meshes assay 0.6 per cent. in copper, and the value increases, so that at about 200-mesh the assay has risen to 1.30 per cent.

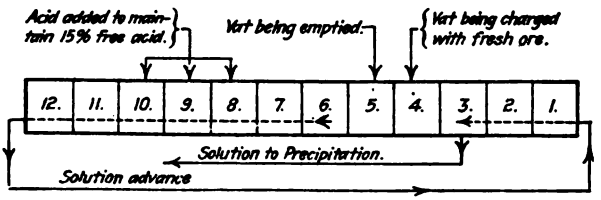

FIG. 7.—Cycle of leaching, Utah Copper Co.

There are 12 leaching vats, 100 by 50 ft. by 17 ft. deep, arranged in a row and occupying a space 100 by 600 feet. They are of reinforced concrete, coated on the sides with mastic 1½ in. thick, on the bottom ½ in. thick. The false bottom has 6 by 6-in. stringers and on these two layers of 2 by 8-in. planks, laid 5/16 in. open, with cocoa matting between the layers. For the transfer of solution there are twelve 6-in. acid-proof pumps and two Ingersoll-Rand single-stage compressors, each of 1350 cu. ft. per min. at 20-lb. pressure. The pipes are of redwood coated with paraffin and wound with copper wire, the valves lead-lined, the cast-iron fittings lined with mastic.

The crushed ore is carried from the mill by a 42-in. inclined belt-conveyor and discharges upon a 4-ft. pan-conveyor, having a transverse slot where one part in 400 is removed as a heads-sample. The pan-conveyor delivers to a hopper which feeds a 42-in. belt-conveyor extending 600 ft. to the far end of the vats. The belt-conveyor discharges by means of its

[1] *Min. Sci. Press*, **117**, 787; MINERAL INDUSTRY, **26**, 205 (1917).

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tripper, which travels with the loading bridge, the discharge falling upon the conveying-belt of the bridge. This bridge conveying-belt also has a tripper which, combined with the movement of the bridge, can be set to discharge at any part of any vat. The filling follows the same method as is used at Chuquicamata. The ore is dropped along one side of the vat and keeps so feeding until the toe of the slope reaches the opposite side. Then filling recommences from the opposite wall until the V-shaped space has been filled. The vats are filled and emptied in rotation, the cycle of leaching being shown in Fig. 7.

After the solution in No. 6 vat is advanced to No. 7, wash-water is added until the effluent contains no more than 0.08 to 0.05 per cent. copper. This wash-water advancing in the cycle takes up copper, and acid is added in vats 8, 9 and 10 of the series, raising the free acid to 1.24 per cent. From this point the free acid diminishes by dissolving copper, iron, aluminium and ferric phosphate until the solution on the newest ore, in this instance in No. 3 vat, contains 3.16 per cent. copper, 0.37 per cent. iron in ferrous form, 0.95 per cent. ferric iron, and 0.24 per cent. free acid, the intention being that this should be no more than 0.2 per cent. Besides, the leaching of the vats in series by the transfer of solution circulation from bottom to top of the vat is maintained by means of an air-lift operated by the air-compressors. This ends the cycle of operations, which is now started at No. 7 vat, and so in succession. The exhausted tailing is removed from the vat by means of the unloading bridge carrying a Mead-Morrison excavator having a 10-ton grab-bucket, the 4000-ton vat being emptied clean to the false bottom in 8 hours. This bridge can pass over the smaller loading bridge to any desired vat. The tailing is discharged into a hopper, thence into 45-ton railroad cars. The copper loss in the tailings is mainly undissolved sulphides.

The first section of the precipitation vats is made up of 16 concrete vats, each 62½ by 9½ ft. by 6 ft. deep, in four rows, while a fifth row is set lower, to receive and settle the material which drains from the preceding tanks. Adjoining the concrete vats is another series of 27 vats, each 9 by 64 ft. by 3 ft. 7 in. deep. Each vat again has transverse divisions for the up-and-down circulation of the flowing solution. Thus, the length of flow through the concrete vats is 1000 ft., through the wooden ones 1728 ft. The former are best suited for the larger scrap, such as plates, boiler shells, large castings, rods, etc.; the wooden ones take smaller scrap. In the first concrete vat, where the solution enters, are five rotating wooden drums or barrels 8 ft. long, 7 ft. 4 in. in diameter, perforated with ⅝ in. holes and rotating 2 r.p.m. These are loaded with tin cans and other small scrap. As this scrap is corroded by the

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advancing solution, it drops through the ⅝-in. holes to the bottom of the vat. From time to time the accumulated "cement" or thin copper mud is withdrawn by pulling a plug and washing it out with a hose. This, passing over a ½-in. screen to take out the iron and copper-flakes, flows by launder to the concrete settling-tanks, which take the mud from the concrete and wooden precipitation tanks also.

At the settling tanks, as the wash-water accumulates, it is decanted and flows to a larger settling tank, 75 ft. in diameter by 12 ft. deep, where any remaining particles of copper settle. This tank also takes the exhausted solution from the last precipitation vat. The decanted mud of the settling-tanks, dug out by a boom-excavator, which travels on an adjoining track, is loaded into cars, which transport it to the shallow wooden drying-vats. There are three of these, each 60 by 70 ft., where, exposed to the weather, the cement-copper mud is dried out. In the last quarter of 1918 this plant yielded 1,116,509 lb. of copper as precipitate.[1]

The New Cornelia Copper Co.[2]—H. A. Tobelmann and J. A. Potter of this company give a complete description of the plant at Ajo, Ariz., and of its operation from May 1, 1917, to the end of December, 1918, a period of 20 months.

In outline, the ore, crushed to ¼-in. mesh, is leached by an acidified solution, which is then subjected to the action of SO_2 gas to reduce its contained ferric iron; part of the copper is electrolytically deposited, and the solution is then returned to the leaching vats in a closed circuit. To prevent fouling of the solution, due to accumulating sulphates, about one-tenth of it is continuously withdrawn, its contained copper precipitated on scrap-iron, and the exhausted solution wasted. To complete the description of the crushing of Ajo ore for leaching as given in MINERAL INDUSTRY, **26,** 205 (1917), we add the following:

Referring to the general plan of the plant, Fig. 8, two sidings from the railroad main-line handle the loaded cars as they come in. The mine is operated in two 8-hr. shifts, and the coarse-crushing plant runs for the same period, there being no storage between the mine and the plant. A 40-ton crane is installed over the big crusher for handling parts in repair and for breaking jams in the bowl of the crusher. From the 10,000-ton steel flat-bottom storage-bin the coarse-crushed ore is automatically withdrawn upon four 20-in. conveying-belts, marked Nos. 2-A, 2-B, 2-C, 2-D, to the fine-crushing plant. This plant is run from 3 p.m. to 7 a.m. to crush 5000 tons, but, due to having the coarse-ore storage-bin, can be operated 24 hr. per day if necessary. Crushing and delivery to a leaching tank proceed together.

[1] *Eng. Min. Jour.*, **106,** 989.
[2] *Bull. Am. Inst. Min. Eng.*, **146,** 449; *Trans.*, **60,** 22.

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The fine dust made is somewhat abated by wetting down the ore on the cars as they come from the mine; the rest of it is taken care of by a dust-collecting system. At this plant the 48-in. Symons disc-crushers are preferred to the rolls used in the early experimental work, the latter producing an undue proportion of fine.

An average screen analysis of the fine-crushed ore shows that 41.9 per cent. of it will lie on a 4-mesh screen, while 19.1 per cent. will pass 20-mesh. The parallel fracture planes of this ore tend to cause it to break

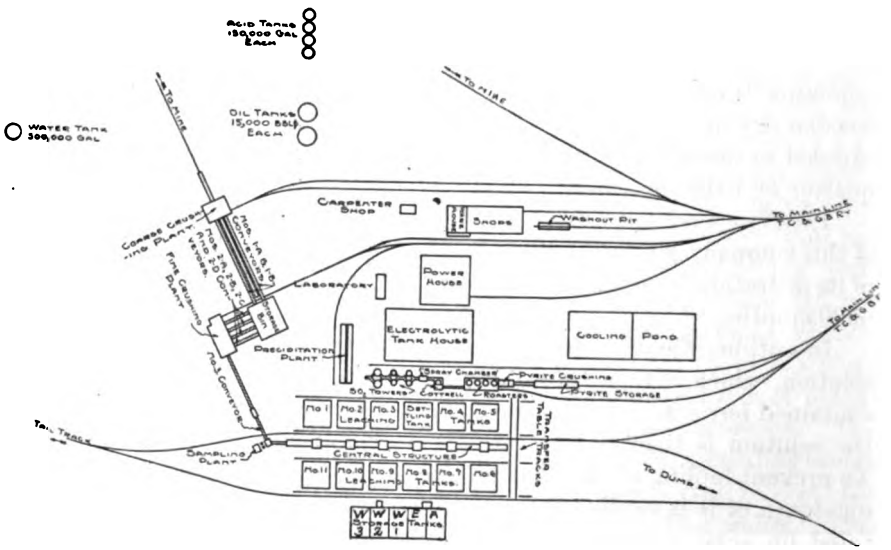

Fig. 8.—General plan of plant, New Cornelia Copper Co., Ajo, Ariz.

into thin flat pieces. These fracture planes contain more or less malachite, and so, as the result of fine crushing, the fines contain more copper than the coarse. Thus the 4-mesh material assays 1.38 per cent., the minus-20-mesh 2.03 per cent. copper. This crushed ore, ready for leaching, is of the following average analysis: SiO_2, 67.04 per cent.; Fe in ferrous form, 3.57; Fe in ferric form, 1.48; Al_2O_3, 12.3; CaO, 0.63; MgO, 1.52; Mn, 0.25; S, 0.05; Cu, 1.57; Cu in soluble form, 1.51; P_2O_5, 0.13; Na_2O, 1.73; Al_2O_3, 3.34; TiO_2, 0.44 per cent.; Ag, 0.161 oz. and Au, 0.014 oz. per ton. It is a well oxidized ore consisting principally of malachite with small amounts of cuprite and chrysacolla distributed through the monzonite-porphyry gangue. The copper in insoluble form as copper sulphide is but 0.05 per cent.

As seen in Fig. 8, the leaching tanks are arranged in two rows of six tanks per row. These are numbered clockwise from No. 1, in order, except that the fourth is reserved as a settling or "sludge" tank. In the

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aisle between the two rows is the central structure which contains launders, conveyors, and pumps. There are two decks, the upper carrying the belt-conveyor, the lower the solution-launder and pipe-lines. Beneath this central structure are two drainage launders for the transfer of solutions from the tanks to one or the other of the solution-storage tanks. The tanks, 88 ft. square by 17 ft. 4 in. deep inside, are of reinforced concrete with wooden bottoms and of 5000 tons capacity each. The walls are 9½ in. thick, buttressed outside. The bottom, supported on concrete foundations, is of 3 by 8-in. planks laid edgewise. The sides and launders of the tanks are lined with 8-lb. lead, the bottom with 6-lb., 4-per cent. antimonial lead. On this comes the filter bottom of 5 by 12-in. joists parallel to the car tracks, laid on edge and covered by 2-in. planks bored at 2-in. centers with ⅜-in. holes, the holes countersunk below. Transverse to and beneath the joists at the center line of each tank is a distributing launder, 5 ft. wide by 2 ft. 9 in. deep, for the delivery and distribution of the solution for upward percolation. The lead lining of the sides of the tanks is protected by 2-in. planks held in place by 6 by 8-in. vertical posts clamped top and bottom. Each tank has overflow launders at the sides, transverse to the tracks, the ends adjacent to the central structure, being connected to the suction of a circulating pump.

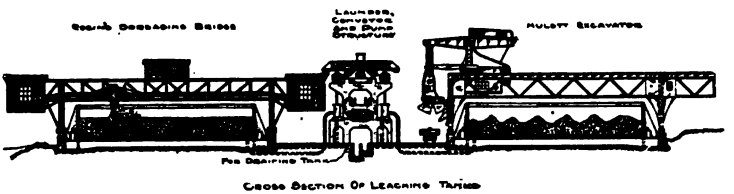

FIG. 9.—Cross-section of leaching tanks.

As shown by Fig. 9, spanning the tanks and travelling the length of the row, is a Robins spreading bridge for charging the ore. This bridge of structural steel supports a 28-in. belt-conveyor, while a tripper on this belt spreads the ore in the tanks. Ore from the fine-crushing plant travels along No. 3 conveyor (see Fig. 8), a small portion being cut out at the sampling plant, then is sent to the longitudinal conveying belt of the central structure. From this, by aid of a short transverse conveyor, it is dropped into the hopper at the adjacent end of the spreading bridge, and so, by the spreading belt and tripper, to the leaching tank. The tanks are charged by filling at one side, allowing the material to take its natural slope, then continuing at that side, dropping the ore at the top of the slope, so that the coarser material rolls to the bottom, the finer higher up, thus instituting a rough classification. The bridge is moved slowly forward as the filling progresses. Thus filled, the first filling at the side

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is more impervious to the solution, the exhausted tailing there containing 0.33 per cent. copper against 0.20 per cent. elsewhere.

The filled tank is leached for 6 to 8 days by a counter-current system and upward percolation. The solution in each tank is circulated by two 15-in. centrifugal pumps of 3500 gal. each (direct connected to 40-hp. electric motors) against a friction head of 28 feet. The pumps are throttled to give a circulation through the ore of 4000 to 5000 gal. per minute. Of this about 1000 gal. per min. called "the solution-advance" is passing from tank to tank. The acid solution, reinforced by addition of sulphuric acid to about 3 per cent., coming from tank-house and solution-storage and going upon the oldest ore, is called "the acid-advance." The nearly neutral solution, coming off the newest charge and going to the reduction towers, is known as the "newest-advance."

Cycle of Leaching Operation.—Referring to Fig. 8, if we assume the ore in tank No. 10 is the oldest, and that in No. 5 the newest in circuit, seven being in process of leaching, then No. 6 is being charged with ore, No. 7 is empty, No. 8 is being excavated, and No. 9 is washing and draining. The group of solution storage-tanks, 90 ft. by 100 ft. by 12 ft. deep, counting from the north end, are marked A, E, W_1, W_2 and W_3.

Tank No. 6 is now charged, and the acid-advance from solution-tanks A and E is increased to 2000 gal. per min. for a period of 4 hours. Meanwhile the usual advance of 1000 gal. per min. is going from tank No. 5 to the SO_2 or reduction towers, and the excess solution is advanced to No. 6 until the ore is covered, this to prevent any interruption of the solution flow to the towers, after which the excess advance is cut off and the normal advance resumed. The solution on the new charge is next circulated on itself for about 4 hr., or until clarified. Tank No. 6 is now put in circuit and the neutral solution-advance to the towers comes off No. 6 instead of No. 5 tank.

Leaching in No. 6 keeps up for 7 days, the free acid in solution climbing regularly from 0.5 per cent. on the first day to 3 per cent. on the seventh. At the end of the seventh day the acid-advance from the tank-house is transferred from No. 10 to No. 11 tank. Upon the entrance of a new charge into the circuit, the solution in the oldest tank is drained to the acid-solution storage-tank, brought up to the standard by addition of acid and later used as acid-advance. After thorough draining this tank is ready for the wash-water. About one-third of the soluble copper still remains entrained in the charge, and this must be washed out. When tank No. 9 has been drained, wash-water from wash-water tank No. 1 is circulated, then drained to the acid tanks A or E, this being the first wash. Solution from wash-water tank No. 2 is similarly circulated and drained to wash-water tank No. 1. In the same way wash-water from

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No. 3 is put on, circulated, and drained. The fourth and last wash (of fresh water) is pumped, circulated, and drained into wash-water tank No. 3. Thus the fourth wash of any one charge is used as the third wash of the next charge, the third for the second and the second as the first. Or, each wash-water is used four times, the copper contents increasing each time, when it is added to the system, thus making up for the losses of solution, due to evaporation, to solution discarded at the precipitation-boxes and to the entrained solution in the tailings (about 11 per cent.). It is estimated that these losses aggregate 57 to 66 gal. per ton of ore. Thus the solution, drained off before the first wash, would average 2.56 per cent. H_2SO_4, the successive washes 1.02, 0.68, 0.48 and 0.10 per cent., while the corresponding copper contents would be 3.40 per cent. for the solution off, and for the washes 1.61, 1.15, 0.74 and 0.38 per cent. respectively.

Since each tenth of a per cent. of copper in the last wash-water represents a loss of 1000 lb. of dissolved copper daily, it is evident that the washing is imperfect. To aid in this respect it has been planned to use a fifth wash-water, precipitating its copper contents on scrap-iron simultaneously.

The Hewlett tailings-excavator,[1] originally used for unloading iron ore at the lower lake ports from the holds of ore vessels, has been adapted at Ajo for the removal of exhausted tailings from the leaching tanks. One tank is emptied of tailings daily in 10 or 11 hours. The several motors used to drive the excavator aggregate 500 horsepower. In operation, after the leaching has been completed, the exhausted tailings are transferred to the tailings cars standing on tracks 10 ft. from the tanks. Excavation from the tank stops 6 in. above the false bottom to avoid injury to it. Men are then sent down to shovel the remainder into winrows, so that at the next emptying it shall be mostly removed. When the operator wishes to move the excavator to a new cut he can do so at the switch-board at the mid-point of the bridge. He loads the cars with little or no spilling, and by combining the various movements, can deliver the 10-ton shovelful every 72 seconds. For the transportation of the tailings two eight-car trains are released from mine service daily, it taking 20 to 23 train-loads to empty a tank. The tailings go to a dump, located about a mile from the plant, the end of the dump being about 80 ft. high. A transfer table is provided at one end of the tanks for the transferring of the spreading bridge and excavator from one row of tanks to the other.

Solution.—For the first year of operation the acid-advance, which contains 3 per cent. acid and 2.4 per cent. copper, varied from 869 to 1324 gal. per min.; the more rapid the advance the better the extraction,

[1] *Min. Sci. Press*, **117**, 303; *Bull. Am. Inst. Min. Eng.*, **140**, 1229; **143**, 1670; **146**, 463; *Trans.*, **61**.

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but with a greater consumption of acid. The neutral-advance retains 0.5 per cent. acid, while its copper builds up to over 3 per cent. Comparison of the analyses of the ore and tailings shows a drop in the percentage of iron, alumina, and magnesia, indicating that a measurable quantity has passed into solution, extraction increasing as leaching progresses. The copper dissolved daily per ton of ore treated varies from 3.66 lb. the first day to 1.24 on the eighth, or 26 lb. in all; and 60° B. acid consumed is nearly 10 lb. daily at first to 20 lb. daily at the last, when the acid percentage has reached its maximum. The total acid used up is 130 lb. per ton of ore, and the 0.7 lb. of copper gained on the last 2 days was at the expense of 43 lb. of 60° B. acid. Thus the time of contact between the ore and the solution may be prolonged to the point when it ceases to be profitable. Of the total acid consumed 60 per cent. is new acid, brought from the outside, 32 per cent. generated in the SO_2 towers and 8 per cent. regenerated in the electrolytic tank-house. For the first year of operation, due to initial troubles, the acid consumption has been 3.36 lb. of 60° B. acid per lb. of copper extracted, while for the last 4 months of 1918 it has been but 2.75 lb. per lb. of copper. Against 1,345,000 tons of ore treated in the first year of operation has been charged 60,000 tons of acid, an average of 89.6 lb. of 60° B. acid per ton of ore. The new acid is purchased from the Calumet & Arizona Co.'s acid plant at Douglas, Ariz., and shipped in 5-ton tank-cars to Ajo, 300 miles distant. It is stored in four 1000-ton steel tanks. A 6-in. pipe-line delivers it to solution-storage or to the tank-house as required. Both this acid and the ore are free from arsenic and antimony, hence the Ajo cathode copper is of the best quality. In operation there is 30,000 to 35,000 tons of solution throughout the plant, representing a tieup of 900 tons of copper and 600 tons of 60° B. acid.

Reduction of Ferric Iron by Sulphur Dioxide.—Before passing to the electrolytic tank-house for the deposition of its copper, the contained ferric sulphate should be reduced to ferrous form, since otherwise electric energy will be used up doing this very thing. The reduction is performed by spraying the solution through towers where it is subjected to the action of SO_2 gas generated from iron pyrite. This pyrite ore is from the Bisbee district, low in copper and carrying 43 per cent. sulphur. Some 75 tons daily is unloaded at the "pyrite storage," Fig. 8, a stock-pile having beneath it a tunnel provided with a 24-in. conveying belt. This delivers the ore to the pyrite-crushing mill, where it is crushed to 3-mesh size. A bucket-elevator and a 20-in. conveyor-belt with tripper delivers the crushed materials to the eight hoppers situated above four 7-hearth Wedge roasters, 22½ ft. in diameter. Here it is roasted to leave about 7 per cent. sulphur in the calcines. The gas evolved from the roast-

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ing, containing 8 to 10 per cent. SO_2, passes through a short balloon-flue to a Cottrell electrostatic treater-unit, having 48 collector-tubes 13 in. in diameter, and using 65,000-volt current. That sulphuric acid may not separate out from the gas, both balloon-flue and the treater are kept hot by a magnesia covering. The gas, now practically clean after its passage through the treater, enters a large sheet-lead cooling chamber, 14 ft. square by 94 ft. long, supported on a wooden framework, and marked on Fig. 8 "spray-chamber." Here, to cool it before it enters the towers, the gas is sprayed with neutral solution by means of 38 spray-nozzles using 90 to 100 gal. per minute. The ferric iron in this solution is reduced to ferrous form, and joins that from the towers. The temperature of the gas is reduced at the same time from 320° to 70° C.

A flue, 6 ft. square by 20 ft. long, connects the spray-chamber with the bottom of the first pair of towers, dividing the gas equally between them. There are six towers (marked "SO_2 towers") arranged in pairs. The first two pairs are 20 ft. in diameter by 40 ft. high, the last pair 28 ft. in diameter by 40 ft. high. The first ones are lined with sheet lead, the last pair are of redwood construction. As a precaution against gas leakage the wooden towers are painted with asphalt and covered with three-ply roofing-paper under the hoops. All the towers are filled with a grillage of $\frac{3}{8}$-in. boards on edge set $\frac{3}{8}$ in. open, each layer of boards at right angles to the next layer.

The solution is distributed over the top of the towers in gas-sealed launders. Between the second and third pair of towers is a 60-in. lead fan. This fan draws the gas through the Cottrell treater, spray-chambers and third pair of towers, and forces it through the second and first pairs to the atmosphere, where it escapes, still containing about 0.8 per cent. of SO_2.

The neutral-advance solution (which is high in copper and low in acid) travels counter-current to the flow of gas, that is, the most reduced solution comes in contact with the strongest gas. Coming from the newest tank of ore, the solution is raised by a 9-in. centrifugal pump to the top of the first pair of towers. Amounting to 1000 to 1300 gal. per min., it is distributed by the launders and gas-seals, and flows down over the filling, thus coming in intimate contact with the rising gas. At the bottom of each pair of towers is a concrete lead-lined sump, 6 ft. deep and 50 ft. long. Into this flows the solution, which is then pumped through the next pair of towers.

From the first pair of towers the solution is pumped to the second pair, to the third pair, and then to the so-called settling tank in the first row of leaching tanks. The purpose of this tank is two-fold, one is to settle out the slime, the other to get the benefit of the additional reduc-

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tion that comes on standing. In March, 1918, the average amount of ferric iron in the neutral solution entering the towers was 0.79 per cent., on leaving them 0.17 per cent., and on standing in the settling tank but 0.10 per cent. The reaction in the towers between the ferric iron and the sulphur-dioxide gas is in accordance with the equation:

$$Fe_2(SO_4)_3 + SO_2 + 2H_2O = 2FeSO_4 + 2H_2SO_4$$

Per pound of ferric iron reduced, there was consumed in March, 1918, 0.4 lb. of sulphur in the sulphur-dioxide gas, resulting in the estimated production of 66.3 tons of new acid daily. The free acid in the solution entering the towers was 0.48 per cent., on leaving them 1.7 per cent.

From the settling tank the reduced solution now goes to the tank-house. In the electrolytic vats copper is oxidized by the remaining ferric iron to the extent of 70 per cent. of the theoretical amount, so that there should be ample reduction-capacity. This is shown by the poorer reduction at first when there were but four towers, as compared with later results with six. Thus the ferric iron for the first year in the solution entering the tank-house was 0.45 per cent., in March, 1918, but 0.10 per cent. It has been found, moreover, that this reduction is the greatest in the first pair of towers where the ferric iron is the highest, the reductions being 49.5, 27.5, 16.0 and 7.0 per cent. for the three pairs of towers and the settling-tank respectively.

Electrolytic Deposition.—The electrolytic tank-house is 166 ft. wide by 280 ft. long. It has a cellar floor, graded to gutters which lead to a pump at each end of the building. The cellar is open on all sides, and has a head room of 8 ft. to the electrolytic tanks, to permit inspection of the tanks, piping, and feed-wires.

The tanks, all on a level, are arranged in banks with aisles between. They are supported on concrete columns, are insulated by the blocks covered by sheet-lead caps, and are set 3 in. apart. There are 12 banks of 10 tanks each and 4 banks of 8 tanks each, making a total of 152 tanks. Each tank is 29 ft. 7 in. long, 4 ft. 9 in. wide, and 4 ft. 3 in. deep, all inside dimensions, is of Oregon pine, lined with 7-lb. sheet lead, and is provided with a 4-in. clean-out plug. To assure uniform circulation of the solution there is a perforated sheet-lead diaphragm at each end of the tank. Behind the diaphragm, at one end, is the solution inlet fitted with a 3½-in. valve and a 3½-in. goose-neck. At the other end the outlet has a lead overflow-pan with a 4-in. tile-pipe suspended in a 10-in. lead-boot, this boot connecting to the discharge pipe. Each tank has 84 anodes, making a total of 12,768 in the tank-house. These anodes are of lead containing 3.5 per cent. antimony. They are 41 by 51 in. by ¼ in. thick and weigh 215 pounds. Each anode is suspended

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in the tank at 4½-in. centers by two ¼ by 1¼-in. copper bars secured along its upper edge, and clears the tank bottom by 8 in., the submerged surface being 41 by 41 inches. Short circuits are prevented to some extent by attaching to each face of the anode four conical glazed porcelain insulators, serving as spacers between anode and cathode. The anodes have proved to be durable, with little oxidation and no loss of weight. There are 77 cathodes per tank, or 9779 in the tank-house, exclusive of starting-sheet blanks. This figure is on the basis that at the north end of the tank-house three of the banks, each of eight tanks and one tank of the fourth bank, 25 in all, are used for making starting sheets. This leaves 127 tanks for making copper. The cathodes are 42 by 42 in., submerged to clear the tank bottom by 7 in., and suspended by loops made from stripping sheets from ¼ by 1¼-in. copper bars. The starting-sheets weigh 15 to 18 lb., the finished cathodes 130 to 140 lb., made in 14 to 16 days. Two 5-ton traveling cranes serve the tanks. One section of 11 cathodes is removed from the tank at a time by aid of a lifting rack, carried to the transverse center aisle, and there washed clean. They are then landed on iron frames to facilitate trucking to the freight cars. A drilled sample is taken from each twentieth cathode, and the cathodes, with any scrap, are shipped to the Perth Amboy refinery for remelting and casting into commercial shapes. The cathodes vary from 99.15 to 99.85 per cent. in copper, from 0.05 to 0.35 chlorine, and less than 0.0015 arsenic and 0.0005 per cent. antimony.

For each of the 25 tanks making starting sheets there are 77 starting blanks, or a total of 1925 blanks. One bay of the tank-house of 25½ ft. is reserved for a stripping floor. The starting blanks of lead, containing 3½ per cent. antimony, are 53 by 43 by ¼ in. thick to allow subsequent trimming of the starting sheet. Grooved redwood sticks slipped over the edges and bottom of the blank cut the sheet edges and facilitate the stripping. Four men can strip at best 924 sheets in 5 hours. The sheets are now trimmed and looped on a standard Morrow machine. The electrodes are parallel to the length of the tank, that is, parallel to the flow of the solution, thus giving it free circulation. Alternate busbars are laid in lines across the tanks, forming spaces or "cells," the anodes being spaced between the bars. The end busbars are 1 in. wide by 4 in. deep, the intermediate ones 1½ in. by 4 in. deep. They rest on insulated iron castings, these in turn resting on the tank-cleats. Soldered along the top of each busbar is a triangular bar of copper ½ in. high, giving a point contact to the electrode suspending bars. Small maple blocks soaked with linseed oil alternately insulate the electrodes. Current is supplied by two 15,000-amp. circuits, each carrying 76 tanks in series, equal to a current density of 8 amp. per sq. ft. of cathode surface. With a

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current efficiency of 80 per cent., this means a gain of 10.25 lb. per cathode, or a total capacity of 120,000 lb. of electrolytic copper daily. The drop of potential between anode and cathode averages close to 2 volts.

The solution flow, from 800 to 1500 gal. per min. in the tank-house, is in closed circuit with the leaching tanks and the reduction plant, the volume divided among the 16 banks of tanks so that each bank receives 60 to 70 gal. per minute. Each bank-unit of from 8 to 10 tanks has its own sump, its own 9-in. centrifugal pump and its own circulation between it and the sump, and an overflow for the return of such portion of the electrolyte as is equivalent to the reduced solution added.

Comparing the analysis of the solution entering and that leaving the tank-house in March, 1918, we note that the copper was reduced from 2.99 to 2.25 per cent., 0.47 per cent. having been deposited on the cathodes; also that the ferric iron had risen from 0.09 to 0.75 per cent. while other bases remain unchanged. The free acid increased from 1.7 per cent. in the neutral- to 2.1 per cent. in the acid-advance leaving the tank-house, the 0.4 per cent. thus regenerated being 65 to 70 per cent. of the theoretical amount. In the month 3,152,800 lb. of copper was produced and 3.9 per cent. of the total copper was shipped as scrap. The average weight per cathode was 130 pounds. The temperature of the entering solution was 30° C. (86.5° F.), and when leaving, 34.1° C. (93.4° F.). Its specific gravity was 1.31.

Some 45 to 50 per cent. of the total acid in the solution serves to dissolve the copper, the rest to dissolve the bases, these impurities making the solution sluggish in dissolving copper. To keep the solution active about 10 per cent., say 90 gal. per min., must be discarded and replaced by fresh water. Now, since it costs 2 cts. per pound more to produce cement copper than electrolytic, not only should the amount discarded be as small as possible, but it should be the most impure. To meet these requirements the flow in two electrolytic banks of 10 tanks each are connected in series, the effluent then going to the scrap-iron precipitation-launders. The solution entering the first bank may contain 3.14 per cent. copper, 0.95 per cent. H_2SO_4, and 0.45 per cent. ferric iron, while in effluent from the last bank the copper has dropped to 2.12 per cent., the acid has increased to 2.34 per cent. and the ferric iron to 1.44 per cent. This discard solution, thus treated, yields a small amount of cement copper, and due to the increased acid, is more active, while the precipitate is readily washed from the scrap-iron.

The precipitation plant (see Fig. 8) comprises both reinforced-cement and wooden launders or vats. There are six cement launders, each 60 ft. long, 10 ft. wide, and 4½ ft. deep, in which is placed the heavier scrap-iron, resting on a grated wooden floor. The bottom of the launder slopes

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toward three side clean-out grates. There are eight wooden launders, which take the smaller scrap-iron. One of them is 14 ft. wide by 2½ ft. deep, seven of them 10 ft. wide by 3½ ft. deep, all of them 280 ft. long. The capacity of all the launders is 94,600 cu. ft. or 709,500 gallons. Connections between the two kinds is by a 6-in. lead pipe-line. About half the copper is precipitated in each set, the solution being run through them all in series. When a launder is no longer efficient it is by-passed, the launder drained, and the cement copper shoveled out upon wooden platforms where the iron is hand-picked. Recently, near the wooden launders, a concentrate sump, 20 ft. wide, 3 ft. deep by 75 ft. long, has been constructed, into which the cement copper can be flushed and there washed. A locomotive crane removes the precipitate to shallow wooden bins where it is dried for shipment. The exhausted solution is wasted to the desert, containing but 0.02 per cent. copper and 0.08 H_2SO_4. The ferric iron entering the launders is 1.44 per cent., reduced at the expense of the scrap-iron to 0.08 per cent., while the ferrous iron has risen to 4.54 per cent. The other impurities are as indicated by analysis of the flow to the precipitation launders. This is Al_2O_3, 2.47 per cent.; MgO, 1.36; MnO, 0.04; CaO, 0.06; P_2O_5, 0.13 and Cl, 0.11 per cent.

The power house, of structural steel, 200 ft. long by 126 ft. wide, contains five 823-hp. Sterling boilers, equipped with economizers, and an automatically controlled fuel supply. About 600 bbl. of oil is consumed daily. It is supplied through a 6-in. oil line from two steel oil tanks, 60 ft. in diameter by 30 ft. high. Steam at 240-lb. pressure goes to either of the two turbo-generators, each of 7500 kilowatts. Either of these can handle the entire plant load. Each of them exhausts to a Wheeler surface-type condenser.

A summary of results for the year 1918 shows:

Total ore charged to the plant, 1,760,862 dry tons or 355 vats full, containing 1.405 per cent. of copper in soluble form. The tailings still retained 11 per cent. of solution as moisture and 0.227 per cent. of soluble copper. The average time of leaching was 7.59 days. The circulation through the leaching tanks was 4500 gal. per min., out of which 1139 gal. constituted the solution-advance. The neutral-advance, coming off the newest ore, of specific gravity 1.318, contained 0.42 per cent. of acid, while the free acid in the acid-advance was 2.9 per cent. The total acid of 60° B. charged to the plant was 63,185 tons, being 71.2 lb. per ton of ore, and 2.97 lb. per lb. of copper dissolved. The electrolytic copper shipped was 31,745,480 lb. of 99.49 per cent., while 11,382,487 lb. of copper was shipped in the form of precipitate of 54.46 per cent. copper. Of the total production 77.26 per cent. was electrolytic, 22.74 per cent. cement copper.

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CRYOLITE

Cryolite is a double fluoride of sodium and aluminium having the composition $3NaF.AlF_3$. One of its main uses is as a solvent for alumina in the production of aluminium, the solution forming the electrolyte from which the metal is deposited in the molten state. It is also used for the manufacture of white enamel for iron ware.

The world is dependent for its supply on the deposit at Ivigtut, Araukfjord, South Greenland, owned by Kryolith Mine and Handelsselskabet, A/S, Copenhagen, Denmark, which holds a state concession for the mining. The product is sold to the Pennsylvania Salt Manufacturing Co. of Philadelphia, selling agents for America, and to Oresunds Chemiske Fabriker, Kommanditselskab ved C. F. Jarl, Copenhagen, selling agents for all other countries.

The annual shipments from Greenland are as follows, in metric tons:

	To the United States.	To Copenhagen.	Total.
1913	1,964	8,451	10,415
1914	4,139	7,373	11,512
1915	3,753	5,809	9,562
1916	3,773	9,812	13,585
1917	3,959	5,678	9,637
1918	1,916	8,802	10,118

The Department of Commerce reports the following imports for the corresponding years:

	Long Tons.	Value.	Value per Ton.
1913	2,559	$52,557	$20.54
1914	4,612	94,424	20.47
1915	3,940	82,750	21.00
1916	3,857	165,222	42.83
1917	4,383	218,500	49.85
1918	1,950	97,500	50.00

These figures show that there are constant imports of cryolite, sometimes considerable in amount, that are not shipped directly from Greenland to the United States. They also show the increase in price incident to war conditions.

A large proportion of the United States imports are re-shipped to Canada, where aluminium is manufactured on a large scale. The Canadian imports, almost entirely from the United States, are as follows (for fiscal years ending March 31 of the succeeding calendar year):

	Short Tons.	Value.	Value per Ton.
1913	1,234	$50,905	$41.25
1914	1,075	44,683	41.56
1915	1.765	72,024	40.81
1916	860	87,146	101.33
1917	685	131,236	191.59
1918	732	137,258	187.43

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FELDSPAR

By Arthur S. Watts

The feldspar industry has been abnormally active during the year. The largest users are the porcelain and pottery industries and these have been very active on account of the lack of European competition. On the other hand the lack of labor both in mining and manufacturing has been a handicap which has raised the cost of the crude rock and also the cost of the prepared material. The selling cost of first-quality ground feldspar has increased about 40 per cent. in the past 3 years, and is reported as averaging $12.00 per short ton in 1918.[1]

The largest center of crude feldspar production at present is along the Carolina, Clinchfield, and Ohio Railroad in Mitchell and Yancey counties, North Carolina. This district, which was opened in 1912, has now been established as a permanent producer and the quality of the feldspar produced is regulated by the care exercised in mining and selection of crude stock. The average North Carolina feldspar is probably higher in potash and lower in soda than any other American feldspar. This has given it a reputation as a hard feldspar due to its higher fusion temperature when fused alone. When carefully selected and blended with other feldspars carrying a higher soda content, it produces a product that is of the highest quality for ceramic uses, due to its notable freedom from iron-bearing impurities.

UNITED STATES PRODUCTION OF FELDSPAR IN SHORT TONS

Years.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1912	26,462	$ 89,001	60,110	$431,561	86,572	$520,562
1913	45,391	148,549	75,564	628,002	120,955	776,551
1914	85,905	263,476	49,514	366,397	135,419	629,873
1915	60,811	188,443	52,958	440,913	113,769	629,356
1916	84,185	251,372	48,496	450,906	132,681	702,278
1917	.....	.....	.....	.....	141,924	728,838
1918	.....	.....	.....	.....	98,816	674,745

The center of next importance based on production and also quality is Maine. The producing district extends from Auburn, Androscoggin

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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County, southeast through Cumberland County to the Atlantic coast. The feldspar mined in Maine is chiefly of the potash pegmatite variety, although the feldspar mined on Mt. Apatite near Auburn is generally somewhat higher in soda and hence more fusible than other Maine feldspar. The uniformity of the Maine feldspar over a long period of years has established for it an enviable reputation.

The center of next importance and the only other large feldspar-producing center in America is around Verona, Ont., Canada, on the Kingston and Pembroke railroad. This Canadian feldspar occurs in massive form practically free from quartz, and consists of approximately 75 per cent. potash and 25 per cent. soda feldspar. It is hence more fusible than most potash feldspars of the United States. It occurs as a salmon-colored material, while practically all the feldspars of the United States are cream to buff color. The intense color of the Canadian feldspar disappears on fusion and the products in which it is used are only slightly, if at all, inferior in color to those in which pure feldspar from the United States is used. The production of feldspar from the Ontario district has increased greatly in the past 3 years, so that the 1918 output was approximately equal to that of Maine.

The three centers mentioned produce about 65 per cent. of the total feldspar used in the United States. The remaining 35 per cent. is mined in Connecticut, New York, Pennsylvania, Maryland and California in approximately equal amounts.

The user of feldspar is beginning to realize that the same knowledge is desirable regarding the feldspar that enters into his mixtures as he has found necessary with regard to the clays he uses. The problem is furthermore much simpler with feldspar than with clays.

CRUDE AND GROUND FELDSPAR SOLD IN 1916, 1917 AND 1918(a)

State.	1916.		1917.		1918.	
	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.
California	1,400	$6,550	7,874	$18,543	1,452	$8,839
Connecticut	12,333	76,979	(b)11,710	77,432	5,942	29,419
Maine	28,006	235,922	35,527	291,252	25,375	105,430
Maryland	23,928	83,957	15,779	56,958	8,340	38,369
New York	17,426	82,461	13,462	62,003	12,737	58,605
North Carolina	34,670	77,446	47,559	131,442	40,020	160,275
Pennsylvania	7,342	56,323	10,013	91,208	4,950	27,838
Virginia, Georgia, New Hampshire, and Vermont	7,576	82,640	.....	.....	.....	.....
Canada	19,488	71,407	19,462	89,826	20,232	117,379

(a) Statistics furnished by U. S. Geol. Surv.; Canadian figures from the Canadian Dept. of Mines.
(b) Includes New Hampshire.

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Practically all the feldspar used in the United States is ground by ten companies, viz.:

Maine Feldspar Co., Brunswick, Me., operating mills at Topsham and Auburn, Me., and grinding Maine feldspars exclusively.

Trenton Flint and Spar Co., Brunswick, Me., operating a mill at Cathance, Me., and grinding Maine feldspar exclusively.

L. W. Howe, South Glastonbury, Conn., operating a mill at South Glastonbury, Conn., and grinding Connecticut feldspar exclusively.

Bedford Mining Co., Bedford, N. Y., operating two mills at Bedford, N. Y., and grinding potash and soda feldspar from Westchester County, N. Y., exclusively.

The Golding Sons Co., Trenton, N. J., operating mills at Trenton, N. J., Wilmington, Del., and East Liverpool, Ohio, and grinding Maine, Maryland, North Carolina and Canadian feldspar, both pure and blended.

Eureka Flint & Spar Co., Trenton, N. J., operating a mill at Trenton, N. J., and grinding Connecticut, New York, Canadian and North Carolina feldspar, both pure and blended.

Pennsylvania Feldspar Co., 404 Harrison Bldg., Philadelphia, Pa., operating a mill at Genesee Docks, N. Y., which grinds Canadian feldspar exclusively, and a mill at Toughkenamon, Pa., which grinds Pennsylvania feldspar exclusively.

Dominion Feldspar Corp., Barnard, N. Y., operating a mill at Genesee Docks, N. Y., and grinding Canadian feldspar exclusively.

The Potters Mining and Milling Co., East Liverpool, Ohio, operating a mill at Laughlin, Ohio, and grinding Canadian and North Carolina feldspar.

Clinchfield Products Corp., 120 Broadway, New York, operating a mill at Erwin, Tenn., and grinding North Carolina feldspar; also agents for Bedford Mining Co., ground feldspar.

Brandywine Summit Kaolin and Feldspar Co., Brandywine Summit, Pa., mill destroyed by fire, Dec. 20, 1918.

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FLUORSPAR

Fluorspar mining in 1918 was exceedingly active, new deposits in Arizona, New Mexico, and Colorado making production. The placing of an embargo, by the War Trade Board, on fluorspar importations, together with the rise in prices and increased demand, greatly stimulated domestic production. The domestic production of 1917 was 280,825 short tons, according to the U. S. Geological Survey, and the production for 1918 was 326,039 short tons, an increase of 16.1 per cent. The amount as estimated is considerably less than it might be if sufficient labor, machinery, and other supplies were available. Stocks of spar at mines or shipping points, mainly in Kentucky, amounted at the end of 1918, to 22,779 short tons, compared with 21,655 tons at the end of 1917. The following table shows sales for the last three years:

DOMESTIC FLUORSPAR SOLD, 1916–1918

State.	Gravel.			Lump.			Ground.			Total.		
	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.
1916.												
Illinois... Kentucky	123,983	660,714	5.33	14,489	114,993	7.94	7,595	94,039	12.38	146,067	869,746	5.95
Other States (a)	(b)9,668	52,908	5.47	(b)	(b)	.....	.....	.....	.....	9,668	52,908	5.47
	b133,651	713,622	5.34	14,489	114,993	7.94	7,595	94,039	12.38	155,735	922,654	5.92
1917.												
Colorado	11,140	94,365	8.47	5,964	102,268	17.15	.....	.....	.....	17,104	196,633	11.50
Illinois..	136,954	1,111,348	8.11	19,584	247,192	12.62	10,136	178,342	17.59	156,676	1,373,33	8.77
Kentucky	33,641	534,017	15.87							43,639	697,566	15.98
Others (a)	(b)1,409	(b)20,190	14.33	(b)	(b)	.....	.....	.....	.....	1,409	20,190	14.33
	b183,144	1,759,92[illegible]	9.61	b25,548	349,460	13.68	10,136	178,342	17.59	218,828	2,287,722	10.45
1918.												
Arizona..	.....	.....	.....	364	5,537	15.21	.....	.....	.....	364	5,537	15.21
Colorado.	9,870	134,816	13.66	28,605	281,964	9.86	.....	.....	.....	38,475	416,780	10.83
Illinois...	122,721	2,565,394	20.90	9,518	260,948	27.42	8,752	273,203	31.22	132,798	2,887,099	21.74
Kentucky	79,411	1,856,739	23.38							87,604	2,069.185	23.62
N.Mexico	b1,309	25,507	19.49	3,267	61,373	18.79	.....	.....	.....	3,437	64,348	18 72
Other States (a)										1,139	22,532	19.78
	b213,311	b4,582,456	21.48	b41,754	b609,822	14.61	8,752	273,203	31.22	263,817	5,465,481	20.72

(a) Includes, 1916: Arizona, Colorado, and New Hampshire; 1917: Arizona and New Hampshire; 1918: New Hampshire, Utah and Washington.
(b) Some lump spar is included with gravel.

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SALES OF FLUORSPAR IN THE UNITED STATES, IN SHORT TONS (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1903	42,523	$213,617	1911	87,048	$611,447
1904	36,452	234,755	1912	116,545	769,163
1905	57,385	362,488	1913	115,580	736,286
1906	40,796	244,025	1914	95,116	570,041
1907	49,496	287,342	1915	136,941	764,475
1908	38,785	225,998	1916	155,735	922,654
1909	50,742	291,747	1917	218,828	2,287,722
1910	69,427	430,196	1918	263,817	5,465,481

(a) Statistics of U. S. Geol. Surv.

Commercial Grades and Requirements

Fluorspar is placed upon the market in three grades, lump, gravel, and ground. The silica limit for lump and gravel spar is 6 per cent.; for spar to be used in the ceramic industry, 3 to 5 per cent., and for spar to be used in the production of hydrofluoric acid, 1 per cent. Lead or zinc compounds are objectionable to ceramic manufacturers, and an excess of 1 per cent. calcium carbonate is objectionable to acid makers. Standard specifications for metallurgical fluorspar require that the mineral contain not less than 85 per cent. CaF_2 and not more than 5 per cent. silica.

Prices during 1918 were erratic, but $25 per long ton would represent the average price for fluxing grade and $40 for ground fluorspar.

The demand for fluorspar is principally for metallurgical purposes in the basic open-hearth steel process. There is an increasing use in electric-furnace plants and in the electrometallurgical industry. In the chemical industry there is an increasing demand for the higher-grade fluorspars. The demand for optical fluorite is limited, but would increase if sufficient quantities could be produced at reasonable prices. Only perfect crystals are suitable for optical use. The value of optical fluorite is approximately $1 per lb., though large, fine specimens may bring $10 apiece.[1]

FLUORSPAR IMPORTED, IN SHORT TONS (a)

	Quantity.	Value.	Average Price per Ton.
1911	32,764	$80,592	$2.46
1912	26,176	71,616	2.74
1913	22,682	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19
1916	12,323	52,976	4.38
1917	13,616	114,598	8.42
1918	12,572	169,364	13.47

(a) Statistics according to Bureau of Foreign and Domestic Commerce, Department of Commerce.

[1] *Eng. Min. Jour.*, Jan. 25, 1919.

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Industry Preceding and During the War[1]

Prior to 1905 the production of fluorspar was less than 50,000 short tons annually; up to 1908 it fluctuated considerably, but in 1909 it began to increase rapidly, owing to the more general recognition of the value of fluorspar in the manufacture of open-hearth steel and to the expansions in facilities for mining and milling the mineral in Illinois and Kentucky. There was a steady increase in production from 1908 to 1912, but in 1913 and 1914 there were decreases coincident with depression in the steel industry. In 1915 and 1916 the production largely increased, owing to the revival of the steel and chemical industries, the output for both of these years exceeding all previous records. Since 1910, there has been an almost steady decrease in imports, but the considerable falling off during the war years may be attributed to the interruption to commerce as well as to depression in the mining industry in England caused by the scarcity of available miners.

The Underwood bill reduced the duty to $1.50 a ton in October, 1913. Gravel spar from England has always competed with the domestic product at the steel furnaces on or near the Atlantic seaboard and at times as far west as Pittsburgh and has practically fixed the price in that territory, but since imports have been curtailed the domestic product has been in greater demand and has sold at better prices in the eastern market.

Supplies[1]

No attempt has ever been made to estimate the fluorspar reserves in the United States. Field work by the United States Geological Survey and the Kentucky Geological Survey has shown conclusively, however, that the deposits in Illinois and Kentucky are of sufficient extent to supply for many years demands much greater than at present. Reconnaissance by the Federal Survey indicates that Colorado, New Mexico, and New Hampshire possess deposits that may be drawn upon to supplement the supply from the larger deposits for a considerable period. Moreover, the deposits reported to have been discovered in numerous other states promise to yield commercial quantities of spar from time to time as transportation facilities are developed. The geologic relations of the known deposits indicate that many more of similar grade and extent should be discovered as prospecting progresses in mining regions in the Central and Western States. If the demand should ever greatly exceed the supply from the present principal domestic sources a considerable quantity might be obtained by saving the concentrates at metalliferous

[1] E. F. Burchard, *Bull.* 666-CC, U. S. Geol. Surv.

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mines, although this would involve in most places the separation of fluorspar from other gangue minerals, and the price would have to be much higher than at present to render this procedure profitable.

Colorado.[1]—In 1917, high transportation costs prevented Colorado producers from competing with those of Missouri, Illinois, and Kentucky. Shortage of freight cars during 1918 enabled Colorado producers to supply the local demand, the largest consumer being the Colorado Fuel and Iron Co., at Pueblo. Other Western demands were met by producers of Yuma County, Ariz., and from deposits in New Mexico. In Colorado, the principal producers are the American Fluorspar Mining Co., at Wagon Wheel Gap, making a production of 50 tons per day, and the National Ore and Metals Co., of Boulder, making a production of 1000 tons per month. Other deposits are at present being mined in Custer and Jefferson counties.

The price of Colorado fluorspar was $22 per long ton, f.o.b. point of shipment, late in 1918.

Kentucky-Illinois.—The Kentucky-Illinois field produces approximately 90 per cent. of the spar mined and consumed in the United States. The Illinois production comes very largely from two mines, located in Hardin County; that from Kentucky comes from ten or twelve mines, scattered over Crittenden, Caldwell and Livingston counties, but chiefly located in Crittenden County.

Since the signing of the armistice, practically no new business has been booked in this field, with the result that 75 per cent. of the mines have discontinued production and shipping. There is no storage of spar in the district worth speaking of, and owing to lack of employment the mining organizations of the districts, composed very largely of native labor, are leaving the mine settlements and returning to their homes.

Production costs have gone up enormously within the last 4 or 5 years, due in the main to high cost of labor and materials, combined with a further fact that practically all of the easily mineable spar had been taken out in previous years, when the Kentucky field, operating under the disadvantage of long wagon-hauls over bad roads, was not able to compete with other producers on any other basis than to skim the cream from their properties.[2]

Wages advanced in the fluorspar district of Kentucky over 100 per cent. in 1918, but failed to draw sufficient labor. Car shortage and railway embargoes in the first quarter interfered with shipments. Motor trucks largely supplanted wagons for haulage to shipping points. Fluorspar was classed as a war mineral too late to stimulate its production.

[1] *Eng. Min. Jour.*, Jan. 25, 1919.
[2] E. V. Rawn, *Iron Age*, Mar. 27, 1919.

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Many properties changed hands during 1918 in both the Kentucky and Illinois portions of the fluorspar district, but no substantial new producers were brought in. The chief development brought about by the entrance of new capital was the reopening of old mines. The one transaction of importance during 1918 was the sale of the Kentucky Fluorspar Co., with other mines differently owned, namely, the Susie Beeler and Mary Belle, to one holding company, for $500,000, which company had not assumed a corporate title. Several new concentrators were built, and there was a marked advance in installing more substantial machinery and mine equipment. One important development was the change, on a large scale, from steam to crude-oil-burning plants and electrical installations for pumping.[1]

Foreign Sources

In normal years more than 50 per cent. of the English production of fluorspar has been shipped to the United States. Probably this was a surplus, but it is doubtful whether in the next five years there will be any such surplus available, as the demands in Great Britain are certain to be heavier than before the war. Furthermore the foreign spar is of lower grade than the mechanically treated spar from Illinois and Kentucky and the high-grade vein material of New Hampshire, Colorado, and New Mexico, and as fluorspar is of value chiefly according to its purity, purchasers find that the American product is more efficient and consequently cheaper in the end.

Canada.[2]—The production of fluorspar in Canada is from Madoc, Ontario, supplemented by shipments from a recently opened deposit in Yale district, of British Columbia.

The total shipments during 1918 were 7362 tons valued at $135,712, as compared with 4249 tons valued at $68,756 in 1917.

Eight properties were operated in the Madoc district and the average value of shipment was $18.15, as compared with $16.08 in 1917. Prices have varied with the grade of the product from $15 to $30 per ton. In addition to the Madoc occurrences, a small tonnage is reported to have been mined in the township of Cardiff.

The Consolidated Mining & Smelting Co. is operating the "Rock Candy" fluorspar deposit on Kennedy Creek, Kettle River, Yale, B. C. The company reports very favorable indications for a large tonnage in excess of their own requirements, for export.

[1] *Eng. Min. Jour.*, Jan. 11, 1919.
[2] Prelim. Rept. Min. Prod. of Canada, 1918, Dept. of Mines.

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FULLER'S EARTH

Fuller's earth was in good demand in 1918 and, in consonance with the increase in production of petroleum, showed a large increase in output, notwithstanding the handicaps of shortage of labor and fuel, and unsatisfactory conditions of transportation. A report of the United States Geological Survey on fuller's earth shows that the output in 1918 was 84,468 short tons, valued at $1,146,354, or $13.62 per ton, at the mine. This was an increase of 11,901 tons, or 16 per cent., in quantity and $374,267, or 48 per cent., in value compared with 1917. The production in 1917 was 72,567 short tons, valued at the mine at $772,087 or $10.64 a ton. The increase over 1916 was 4745 tons, or 7 per cent., and $65,136, or nearly 10 per cent., in value. Since its beginning, in 1895, this industry has almost steadily increased until, in 1918, its output and the value and average price per ton of its product were the highest yet attained. The output in 1918 was nearly 12 times greater than in 1895, and the value was nearly 28 times greater.

Fuller's earth is found in many states, but in 1918 it was mined and marketed in only seven. Florida was the leading producer in 1918, having been credited with more than three-fourths of the total output and value. The other states, named in order of production, were Texas, Georgia, California, Arkansas, Massachusetts, and Nevada. The Southern States produced 99 per cent. of the domestic fuller's earth marketed in 1918. The imports of fuller's earth in 1918 formed only 17 per cent. of the consumption.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Year.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
1905.....	25,745	$157,776	15,181	$105,997	1912.....	32,715	$305,522	19,109	$145,337
1906.....	28,000	237,950	14,827	108,696	1913.....	38,594	369,750	18,628	145,588
1907.....	34,039	323,275	14,648	122,221	1914.....	40,981	403,646	24,974	195,083
1908.....	30,517	270,685	12,279	93,413	1915.....	47,901	489,219	19,441	152,493
1909.....	29,561	289,000	12,752	101,151	1916.....	67,822	706,951	15,001	139,664
1910.....	30,857	277,293	16,857	132,545	1917.....	72,567	772,087	16,994	176,417
1911.....	34,668	335,350	18,224	143,594	1918.....	84,468	1,146,354	16,920	226,235

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Nevada appeared for the first time as a producer of fuller's earth. A large deposit of earth in Ash Meadows, Nye County, known as "Death Valley Clay," has been used experimentally in refining petroleum and is said to be excellent for this purpose.

Uses.—Fuller's earth obtains its name from its original use in fulling cloth, but only a little domestic earth is now used in this country for that purpose. It is used principally in bleaching and in clarifying or filtering fats, greases, and oils. It is also used in the manufacture of pigments for printing wall papers, in detecting certain coloring matters in some food products, and as a substitute for talcum powder.[1]

FULLER'S EARTH IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES

Year.	Unwrought or Unmanufactured.			Wrought or Manufactured.			Total.		
	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.
1908	2,363	$16,242	$6.87	9,803	$77,171	$7.87	12,166	$93,413	$7.68
1909	1,802	12,492	6.93	10,950	88,659	8.10	12,752	101,151	7.93
1910	2,160	14,399	6.67	14,427	118,146	8.19	16,857	132,545	7.86
1911	1,881	10,877	5.78	16,343	132,717	8.12	18,224	143,594	7.88
1912	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84
1914	1,468	9,283	6.32	23,509	185,800	7.90	24,977	195,083	7.81
1915	850	5,176	6.09	18,591	147,317	7.92	19,441	152,493	7.84
1916	1,132	7,742	6.84	15,669	131,922	8.42	16,801	139,664	8.31
1917	1,441	11,718	8.13	15,553	164,699	10.58	16,994	176,417	10.38
1918	1,083	12,636	11.67	15,837	213,599	13.48	16,920	226,235	13.37

[1] U. S. Geol. Surv.

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GOLD AND SILVER

By M. W. von Bernewitz

Two main causes seriously affected gold and silver mining throughout the world in 1918, namely, the war and the influenza—both were felt in every country. The effects of the conflict in Europe had been oppressive to production of the precious metals since 1914, but became more so during 1918. Skilled and unskilled men were taken into the armies, leaving a general shortage with inefficient help; wages were raised; the cost of supplies increased from 50 to 300 per cent.; and the cost of extraction rose to an average of 50 per cent. above that in the pre-war year. An ounce of gold worth $20.67 would finally only purchase $10 worth of supplies, or pay 2½ men instead of paying five men. The value of gold is fixed, being the basis of international credit and exchange; therefore, unlike most of the other metals that rose in price or were fixed at a higher point to meet the extra costs, gold remained at $20.67 per oz., receiving no relief. Gold throughout the world was withdrawn from circulation, and the only coins changing hands were silver, nickel and copper. In order to pay for trade balances, the United States used and is using silver, and set a minimum price of $1 per oz. upon the metal, this giving silver producers considerable help. The influenza epidemic was particularly bad in all gold-mining countries of the world, and at many centers resulted in mines being closed for some time, with a consequent reduced gold yield. As embargoes were in force in every country against the use of gold for circulation or to pay debts, silver was the only metal to leave America, and during 1918 exports, mostly to the Orient, amounted to $252,846,464, compared with $84,130,876 in 1917. Imports last year totaled $71,375,699, an increase of $18,035,222.

Gold

Continuing the introduction to this chapter in Volume 26 of The Mineral Industry, wherein the question of the value of gold, the need of gold, the high cost of producing gold, and the relief of producers of gold were discussed, it may be said that considerable agitation was stirred up in all gold-mining countries during 1918, all asking for assistance. At this time, February, 1919, it might be said that the question is closed,

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and gold producers will receive little or no aid, all government commissions being against it.

Space prevents even brief abstracts of the many enlightening discussions on gold during 1918. The *Mining and Scientific Press* was practically the only journal of note in America that gave the subject unlimited space, being in complete sympathy with the movement of producers in seeking aid from the Government. Some of the more valuable papers published in the *Press* are as follows:

"Gold and Credit," editorial and discussion; "Gold Industry and Gold Standard," by Hennen Jennings, a valuable diagnosis; "Gold, Silver,

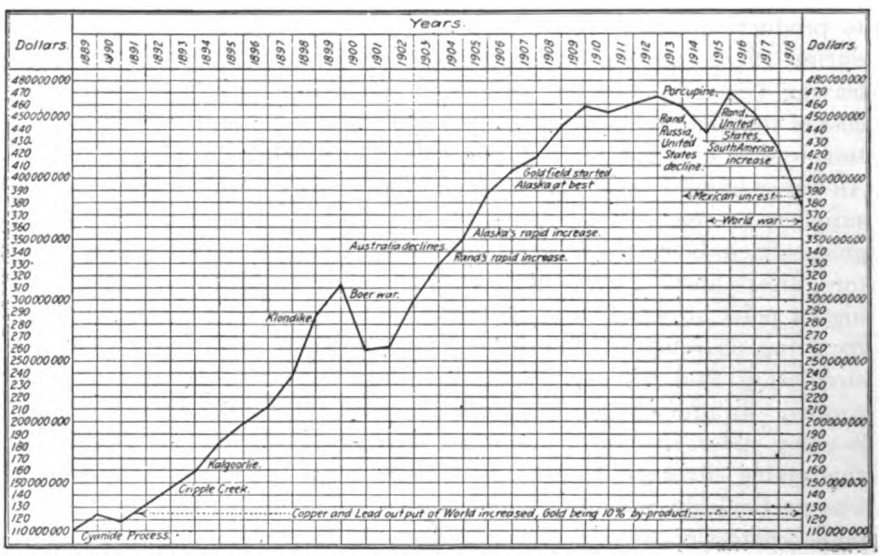

FIG. 1.—Gold production of world for 30 years.

and Credits," an editorial analysis of currency; "Slump in Gold," an editorial based on the annual report of the Dome Mines, Limited, discussing C. D. Kaeding's views; "Gold is Essential," by W. J. Loring; "Financial Safety-valve," editorial on trade, Liberty loans, loans to Allies, credit systems, Federal Reserve notes, and the value of gold; "Relation of Gold to War Finance," by B. L. Thane, who asked why should the gold-mining industry, as established, be compelled to sell its product at a price less than that which it is actually worth; "Sustain the Production of Gold," an editorial covering the views of authorities on gold; "The American Gold Conference," editorial, and article by Courtenay De Kalb, covering the convention at Reno, Nevada; "Gold after the War," editorial; "Inflation and Credits," editorial; "Monetary Adjustments and Gold Mining," by Blamey Stevens, a thoughtful analysis of the present and

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future; "The Gold Problem," by W. deL. Benedict, the writer of a number of papers; "Review of the Gold Problem," by H. N. Lawrie, a statistical and graphical analysis; "Bankers Endorse the Gold Propaganda," and "Financiers Endorse the Gold Propaganda," two editorials discussing the conference of bankers, mine-owners, and financiers in 1918; "The Vital Need for Gold," by John Clausen of the Crocker National Bank, San Francisco; "The Spokane Gold Conference," editorial, and article by Courtenay De Kalb; notes on the conferences at Portland and Chicago; and "Graphics of Gold and Silver," by M. W. von Bernewitz, in which at certain points on the curves were shown the cause of movements in production from 1888 to 1919.

GOLD PRODUCTION OF THE WORLD, BY COUNTRIES

	1916.	1917.	1918.[1]
Transvaal	$192,182,900	$186,503,400	$173,479,000
Rhodesia	19,232,200	17,245,000	12,862,000
West Africa	7,860,100	7,445,600	6,467,000
Congo, Madagascar, etc	3,673,700	3,420,000	3,200,000
Total Africa	$222,948,900	$214,614,000	$196,008,900
United States	$92,590,300	$83,750,700	$68,493,500
Mexico	7,690,700	9,000,000	10,000,000
Canada	19,235,000	15,200,000	14,687,000
Central America	3,517,600	3,122,000	3,000,000
Total North America	$123,033,600	$111,072,700	$96,180,500
Russia, including Siberia	$22,500,000	$18,000,000	$10,000,000
France	1,000,000	700,000	500,000
Other Europe	1,019,900	1,017,000	500,000
Total Europe	$24,519,900	$19,717,000	$11,000,000
British India	$11,206,500	$10,756,800	$10,029,000
British and Dutch E. Indies	3,000,000	2,818,000	2,500,000
Japan and Chosen	9,308,000	9,006,200	8,500,000
China and others	4,495,400	5,035,400	4,500,000
Total Asia, not including Siberia	$28,009,900	$27,606,400	$25,529,000
South America	$15,188,400	$14,634,600	$14,000,000
Australasia	40,475,800	35,945,500	29,800,000
Total for world	$454,176,500	$423,590,200	$372,518,400

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850
According to Dr. Adolph Soetbeer

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

[1] Estimated. Figures from Mint Report for 1916 and 1917.

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GOLD PRODUCTION OF THE WORLD, 1851-1918

Year.	Value.	Year.	Value	Year.	Value.	Year.	Value.
1851...	$67,600,000	1871...	$107,000,000	1891 ..	$130,650,000	1911...	$464,346,495
1852....	132,800,000	1872...	99,600,000	1892...	146,292,600	1912...	474,322,664
1853....	155,500,000	1873...	96,200,000	1893...	158,437,551	1913...	462,669,558
1854....	127,500,000	1874...	90,800,000	1894...	182,509,283	1914...	439,078,260
1855....	135,100,000	1875...	97,500,000	1895...	198,995,741	1915...	470,466,200
1856....	147,600,000	1876 ..	103,700,000	1896...	211,242,081	1916...	454,176,500
1857....	133,300,000	1877...	114,000,000	1897...	237,833,984	1917...	423,590,200
1858....	124,700,000	1878...	119,000,000	1898...	287,327,833	1918...	373,000,000
1859....	124,900,000	1879...	109,000,000	1899...	311,505,947	.....	.....
1860....	119,300,000	1880...	106,600,000	1900...	258,829,703	.....	.....
1861....	113,800,000	1881...	103,102,000	1901...	260,877,429	.....	.....
1862....	107,800,000	1882...	102,000,000	1902...	298,812,493	.....	.....
1863....	107,000,000	1883...	95,400,000	1903...	329,475,401	.....	.....
1864....	113,000,000	1884...	101,700,000	1904...	349,088,293	.....	.....
1865....	120,200,000	1885...	108,400,000	1905...	378,411,754	.....	.....
1866....	121,000,000	1886...	106,000,000	1906...	405,551,022	.....	.....
1867....	104,000,000	1887...	105,775,000	1907...	416,101,396	.....	.....
1868....	109,700,000	1888...	110,197,000	1908...	443,355,856	.....	.....
1869....	106,200,000	1889 ..	123,489,000	1909...	458,424,058	.....	.....
1870....	106,900,000	1890...	118,848,700	1910...	453,766,523	.....	.....

Some instructive papers were also published elsewhere, for instance: Sir Lionel Phillips, of the Central Mining Corporation on the Rand, gave an address on the "Importance of Gold Production;" the *Bulletin* of the National City Bank of New York dealt with "Inflation and Business after the War;" the Minister of Mines for British Columbia approved the suggestion that all taxes be remitted to gold-mining companies, that increased freight-rates be abrogated in favor of low-grade mines, and that gold mining be afforded such assistance as is being granted to other war industries; H. Strakosch, of the Union Corporation of the Rand, circulated a pamphlet entitled "The Value of Gold in our Economic System," in which he did not consider that a bounty would relieve matters.

After much talk on gold, in coöperation with the American Mining Congress, and with the support of numerous Western metal producers' associations, the Governor of Nevada, Emmet D. Boyle, called a conference of gold producers and economists interested in the critical situation in which the gold producers found themselves, to meet at Reno on Aug. 12, 13, and 14, for the purpose of discussing ways and means to stimulate the production of gold in spite of ever-increasing operating costs. The convention was officially organized as the American Gold Conference. Ninety-six delegates came from 11 different states. They included the managers and owners of the majority of the large gold mines of the West. After careful consideration of the situation, it was decided that the most effective measure to maintain American gold production was relief by the Government to the mining companies to correspond with the increased cost of producing the metal, the extent of such relief to be fixed from time to time to meet changing conditions. There was, however, no intention of asking that the amount of gold in the dollar be altered,

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nor to place a premium upon gold. The position was this: the average increase in cost of mining and treating gold ore was 40 per cent., so the relief asked was tantamount to a bonus of $10 per oz. of new gold.

This conference was followed by one at Spokane on Sept. 2, one at Portland at the same time, and a banker's convention at Chicago on Sept. 23. At the last mentioned, gold was only discussed as a side issue.

As a result of the general agitation on gold, the Secretary of the Interior appointed a committee in July, 1918, to study the gold situation. The members were Hennen Jennings, J. H. Mackenzie, Charles Janin, H. D. McCaskey, and F. L. Ransome. The war had not ended when the report was made on Oct. 30. This report has been published as *Bulletin* 144 of the U. S. Bureau of Mines. It covers 84 pages, and is replete with statistical matter in the form of graphs, tables, and discussions—a valuable treatise on the gold industry. The following nine items cover briefly the different measures of relief asked for by the gold-mining industry in response to the questionnaire sent out by the Committee:

(1) Payment by the Government of a bonus on all the newly mined gold. This was qualified by some of the operators who asked that it apply only to primary gold mines, that is, to gold produced at mines where gold is the principal metal and not a by-product. The amount of bonus advocated ranges from $10 to $20 per oz., $10 being the amount nearly always suggested. (2) Exemption from draft of necessary employees and the placing of labor for gold mines in the deferred class. (3) The assistance of the United States Employment Service in securing and maintaining a sufficient supply of labor. (4) Furnishing of supplies to gold mines by the Government at prices nearly in keeping with pre-war figures. (5) The abolishment of the excess-profit tax; to this some added the demand that a larger allowance for depletion for ore extracted should be permitted by Treasury officials in computing tax-charges on profits. (6) Preferred classification for railroad freight, a reduction of the advance in freight-charges for supplies to gold mines and on ore shipments. (7) In California the activities of the Debris Commission are said to cause hardships at some mines. (8) Preferred classification for electric power. (9) Allowance of free export and sale to industry of new gold.

In its conclusions, the Committee stated that the cause of the decrease of gold production was not wholly due to war conditions, but partly to the exhaustion of the most productive lode and placer deposits without equivalent new discoveries taking their places. The general embargo—circulation and export—on gold is injurious to the gold miner. The granting of a bonus, or bounty, has the greatest advocacy from the mine operators, but seemingly such a measure would net the Government only a very small percentage of increase in its present great gold reserve, and then only at great cost. The principle of the bonus appears to be in general economically unsound and its application might result in serious abuses.

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The various measures of relief asked for by the gold-mining industry, with the exception of No. 1, 4, and 6, could easily be granted by executive action without additional legislation. As the profit of a gold mine, no matter how large, cannot be ascribed to war conditions, and, in fact, is seriously handicapped on that account, the remission of this tax is a logical and just demand, and might well be considered. The free export and sale of new gold should be permitted not only because it will help the miner, but also because it gives freedom of movement, thus preventing inflation. Intelligent relief to the most struggling and deserving of the gold mines might be obtained by amending the War Minerals Act to include gold mining, and at the same time voting an appropriation that would be at the disposal of the Administrator to encourage gold discovery and aiding in the reopening of mines shut down on account of adverse economic conditions. This the Committee had pleasure in recommending.

In the Revenue Bill for 1918, passed by Congress in February, 1919, a clause was inserted releasing producers of gold from the excess profits tax. The wording of Section 304 (*d*) is as follows: "In the case of any corporation engaged in the mining of gold, the portion of the net income derived from the mining of gold shall be exempt from the tax imposed by his title, and the tax on the remaining portion of the net income shall be the proportion of a tax computed without the benefit of this subdivision which such remaining portion of the net income bears to the entire net income."

It was announced on Jan. 24, 1919, that the Committee appointed by former Secretary of the Treasury McAdoo to investigate the question of the gold standard reported that special Government or international action is not necessary to stimulate production of gold now that peace is in sight. It was further said that the report, which was to be submitted shortly to Secretary of the Treasury Glass, states that the principal problems arising out of fear that the gold standard throughout the world might not be maintained have been largely removed by the cessation of hostilities.

African, Australasian, and Indian gold producers became further uneasy regarding their position during 1918, all asking that the Imperial Government aid them in some manner, the most popular being a bonus. As late as January, 1919, Australian producers met at Melbourne to consider the situation, with the result that the Commonwealth Government decided to release the hold on gold for a period of three months, as an experiment, during which producers could sell to the highest bidder.

In October, 1918, the British Treasury appointed a strong commission representative of the leading financial interests of the Empire to investigate into the effects of the war on gold production in the British

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Empire. The personnel of this commission included Lord Inchcape, chairman, Sir Thomas Elliott, Sir Charles Addis, and W. H. Goshen. William Frecheville, mining engineer, advised on technical mining problems. This commission made a sweeping inquiry into the conditions at gold mines and possible measures of relief. Especial attention was given to the desirability of granting the demands of the gold producers for a revision of the selling price of their products to compensate for the increase in cost of labor and supplies, to means of encouraging the mining of low-grade ores, and of stimulating the production of gold in general. The producers of South Africa and Australia requested the Treasury to contract for all gold mined by them for a term of ten years at a price calculated to ensure maximum production.

The report of this commission was circulated in January, 1919. Its answers to every suggestion were in the negative. It found that the production of gold in the Empire did not decline during the period of the war, as compared with the corresponding period immediately preceding. The lessened output of the Transvaal in 1917 was due, it is stated, to a shortage of explosives, although shortage of labor was a contributory factor, but this was not due "to any large extent" to the war. The tonnage of low-grade ore treated in the Transvaal has not been diminished by the war. The decreased exploitation of low-grade ore, in favor of richer ore, "will not within any measurable period reduce the output of the Empire" and the continued working of low-grade mines therefore is not "of any great importance to the national interests." The decline in Australasia was "normal and due in the main to natural causes" aggravated by increased costs and deficiency of labor caused by the war. The report concluded by refusing to recommend "any bounty or subsidy for the purpose of stimulating the gold output; gold being the standard of value, no more can properly be paid for it than its value in currency."

Mr. Frecheville's report, while highly instructive, was largely statistical. He reviewed each Dominion of the British Empire, briefly discussing the rise and fall of gold production. Summarizing, he said that, setting the probable increase in Canada against the decrease in Australasia, there remained the anticipated falling off in the Transvaal and a consequent probable decrease of about 4 millions sterling annually in the total gold production of the Empire in the near future. Against this must be set the possibility of unexpected increases and of new discoveries —two factors of such an uncertain nature that it would be idle to attempt to appraise them accurately. There is so much unprospected territory in the Empire that, personally, he looked forward to further discoveries, sooner or later, with a good deal of confidence.

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In connection with new gold fields, attention may be drawn to recent reports regarding the Belgian Congo. It has been known for some time that gold existed in the Kilo district, northwest of Lake Albert Nyanza, and shipments of gold have been made from there for some years. Sir Alfred Sharpe traveled through those parts recently, and an interview with him was published in *The African World* on July 7, 1918, in which he is reported as saying that the discoveries are assuming great importance and give the impression that a large gold field exists there, which is awaiting development, but that up to the present time it has been the policy of the Belgian Government to reserve the deposits, which are both alluvial and reef, as a Government monopoly.

Thus might the story of the efforts of gold producers throughout the world to obtain relief from their unusual burdens be ended; and by the time this chapter is written for the next volume, the curve of the cost of recovering gold should be sharply downward.

"A Creditor Country" was the title of an address by George E. Roberts of the National City Bank of New York before the Investment Bankers Association of America at Atlantic City on Dec. 10, 1918. He said in part:

"The United States Government, in a little over a year and a half, has loaned to governments associated with it in the war over $8,000,000,000, and the Secretary of the Treasury within a few days has asked Congress to authorize additional loans of this character to the amount of $1,500,000,000. In all, including loans privately made and offerings upon the investment market, we will have an interest charge against Europe on account of these transactions of approximately $500,000,000 per year. How is this interest going to be paid? Settlements between countries are accomplished in three ways: The claims may be paid in gold, they may be offset with goods, or they may be settled for the time by means of loans or the sales of securities. Now we know that these interest charges will not be settled in gold, because the total production of gold in the world outside of the United States is less than $400,000,000 per year. And, even if these governments were able to relinquish from their present holdings sufficient gold to make a few payments, the effect of adding gold to our already large reserves would be to raise the level of prices in this country, and maintain prices here above those in the rest of the world, which would place us at a disadvantage with our competitors in world trade. It would make this the best country in the world to sell goods in, and the poorest country in the world to sell goods from. We couldn't afford to take their gold with such results. If we are going to have balances in our favor in every important relation with other countries, how are they going to make payment? There is only one possible way in which it can be done. We will have to capitalize our balances and convert them into foreign investments. We are out in the world to stay, for we never can get our belongings home. It is advantageous for a country whose stock of wealth is proportionately greater than that of the rest of the world to grant aid to other countries less advanced or temporarily short of working capital. In our economic relations our obligations coincide with our largest and best interests.

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Regarding the problem discussed above by Mr. Roberts, it was learned from Washington on January 13, 1919, that the establishment of a gold-settlement fund of several hundred million dollars to facilitate foreign exchange transactions and eliminate the necessity of shipping quantities of gold between countries was under discussion among financial advisers of the Allied Governments and may be arranged at the peace conference. The purpose of this fund, which probably would be deposited in trust with the Bank of England, would be to form the basis for credit transactions between nations in the same way by which the United States Federal Reserve system's gold-settlement fund now constitutes the basis for transfers of credit among Reserve Banks, making it unnecessary to transfer gold within the country. Exchange balances between countries, instead of being settled by actually shipping gold, as would be done in normal times, would be arranged by simple book transactions, with the earmarked gold as guarantee. Allied financiers propose tentatively that $500,000,000 be the maximum size of the fund at first, and that neutral countries be admitted if they choose to participate. Eventually this might become an international gold pool, guaranteeing exchange clearings among all countries. The United States' contribution to the fund as now discussed probably would not be more than $200,000,000. The Government now holds in Treasury vaults more than $2,500,000,000 gold, of which $1,333,000,000 is in the Federal Reserve gold-settlement fund and $882,000,000 as the basis for outstanding gold certificates. Legislation would be required as a preliminary. The fund would be used only for current transactions, not to settle debts now owed the United States by the Allies.

Willingness to undertake development of an international gold exchange fund to facilitate financial transactions between nations without actual shipment of gold was expressed on February 8, 1919, by the Federal Reserve Board, in its report for 1918. This arrangement would be similar to that now maintained by the Board to settle balances between banks within the United States. The fund might be developed among the entente nations and a few leading neutrals, "but it is conceivable that all civilized countries may eventually be participants," said the board. The gold would be deposited in trust in some Government bank to guarantee exchange obligations, and it was proposed that the fund should be limited to current commercial and exchange transactions.

In a 58-page publication, entitled "The World's War Debt," the Mechanics & Metals National Bank of New York presented the following instructive estimates:

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Gross Debt in Millions of Dollars.	Aug. 1, 1914.	Jan. 1, 1919.	Total Wealth.	Per Cent. Debt to Wealth.
United States	1,000	21,000	250,000	8.4
Great Britain	3,500	40,000	90,000	44.4
France	6,500	30,000	65,000	46.1
Russia	4,600	27,000	60,000	45.0
Italy	2,800	12,000	30,000	40.0
Entente nations	18,400	130,000	495,000	26.2
Germany	5,200	40,000	85,000	47.0
Austria-Hungary	3,700	24,000	40,000	60.0
Teutonic nations	8,900	64,000	125,000	51.2
Gross debt, all	27,300	194,000	620,000	31.1
Net debt, all	25,000	182,000	.....	.....

Gross Debt in Millions of Dollars.	Jan. 1, 1920.	Actual Peace Basis Expenses, 1913.	Estimated Peace Basis Expenses, 1920.
United States	26,000	1,000	2,100
Great Britain	42,000	1,150	3,400
France	33,000	1,350	3,000
Russia	30,000	1,800	3,200
Italy	13,000	600	1,100
Entente nations	144,000	5,900	12,800
Germany	45,000	1,100	3,400
Austria-Hungary	26,000	1,000	2,400
Teutonic nations	71,000	2,100	5,800
Gross debt and expenses, all	215,000	8,000	18,600
Net debt and expenses, all	200,000	8,000	18,000

Interest Paid in Millions of Dollars.	1913.	1920.	Annual Income.	Taxes, 1920.	Per Cent.
United States	23.0	1,100	40,000	2,100	5.2
Great Britain	122.5	2,300	12,000	3,400	28.3
France	257.3	2,000	7,500	3,000	40.0
Russia	212.2	1,600	7,000	3,200	45.5
Italy	93.3	600	4,250	1,100	26.0
Entente nations	708.3	7,600	70,750	12,800	18.1
Germany	200.0	2,500	11,000	3,400	30.9
Austria-Hungary	161.7	1,500	5,000	2,400	48.0
Teutonic nations	361.7	4,000	16,000	5,800	36.3
Total annual income	.....	.....	86,750	18,600	21.4
Gross payments, all	1070.0	11,600	.....	.....	.....
Net payments, all	975.0	11,000	.....	.....	.....
Average interest rate, per cent	3.9	5.5	.....	.....	.....

Regarding the proportion of gold to indebtedness in the United States, the late J. K. Lynch, governor of the Reserve Bank in the San Francisco district, estimated that the ratio by June 30, 1919, would be 1:12½, against 1:5 a year previous. The ratio of gold in the world to the indebtedness of the big nations was 1:3 in 1914. Allowing for the production to the end of 1918, according to E. S. Van Dyck,[1] the ratio was then 1:15; and adding other contingent debts, the ratio will be 1:26. The world's annual gold yield of say $400,000,000 is only 3½ per cent. of the interest payable on $280,000,000,000, the world's probable final indebtedness, not considering the metal required to pay trade balances, for circulation, and the arts.

[1] *Min. Sci. Press*, 118, 141 (1919).

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Silver

Producers of silver in 1918 were more favored, so to speak, than producers of gold, as the price of the white metal was eventually fixed at a maximum of 101.5 cts. per ounce.

The past year opened with high prices for silver, the average for January being 88.7 cts., but producers felt the pinch of high costs and other disturbing factors, and began to discuss a method by which they could obtain relief. About the first published discussion on the subject was "An American Policy Regarding Silver,"[1] by Emmet D. Boyle (Governor of Nevada) and Whitman Symmes, manager of several Comstock Lode, Nevada, mines. They compared British and United States interests and ideas of the silver market, the control in London, and considered that

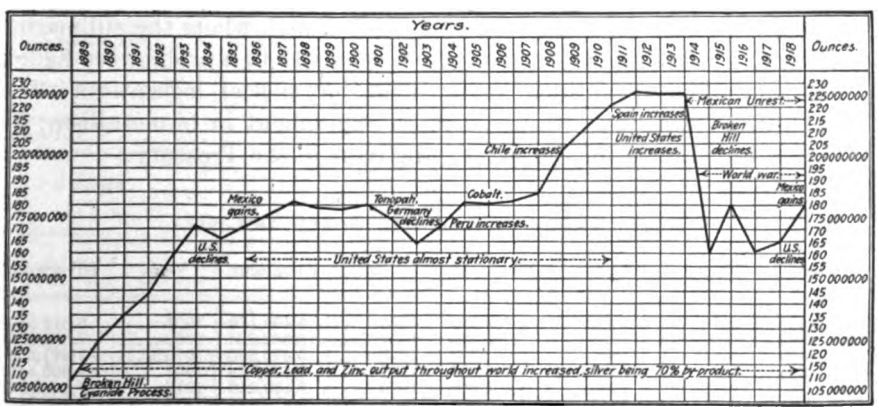
Years.
Ounces.
1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918
Mexico gains.
U.S. declines.
United States almost stationary
Tonopah, Germany declines.
Cobalt.
Peru increases.
Chile increases.
Spain increases.
United States increases.
Broken Hill declines.
Mexican Unrest
World war
Mexico gains.
U.S. declines.
Copper, Lead, and Zinc output throughout world increased silver being 70% by-product.
Broken Hill Cyanide Process.

FIG. 2.—Silver production of world for 30 years.

the price should be fixed by the Government. C. S. Herzig[2] thought that part of their findings was in error, and rather a narrow viewpoint in its contentions regarding Great Britain's influence on the metal.

The Pittman Silver Act, whereby the metal was established at the dollar mark, was reviewed editorially.[3] The Secretary of the Treasury, W. G. McAdoo, in his letter to Senator Pittman, recited the main facts: that more silver was required in order to settle foreign balances, instead of attempting to stabilize exchange by methods that involved future adjustment by means of gold, which is greatly needed at this time as a base for the huge structure of credit created by Government loans. Therefore, 350,000,000 of the silver dollars stored in the Treasury will be converted into bullion. The stock of such dollars is 490,000,000, containing 375,000,000 oz. of fine silver, all represented by outstanding silver

[1] *Min. Sci. Press*, Mar. 3, 1918.
[2] *Min. Sci. Press*, **116**, 540 (1918).
[3] *Min. Sci. Press*, **116**, 606 (1918).

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certificates. These are to be retired as the dollars are taken out of the Treasury and in their place Federal Reserve bank-notes of various denominations (including those of $1 and $2) will be issued. Concurrently the Treasury is authorized to replace the silver thus used, for exchange and export, by the purchase of bullion on the market at $1 per fine ounce, coining this new metal into standard dollars. It is probable that the Government's purchases will absorb the entire output of silver from mines in the United States. The advancing price of all commodities produced in the Orient has given the people of India and China an enormous increase of purchasing power, enabling them to convert their surpluses into silver as never before. The factor gains in importance from the circumstance that freight and insurance across the Pacific from the west coast are considerably less than by the usual route from New York and London by way of the Mediterranean and the Suez Canal, where the submarine menace has raised the insurance against war-risks to a prohibitive figure. These abnormal conditions have called for special legislation. The Pittman Act is a war measure, not an experiment in bi-metallism; its object is to make use of the silver lying inert in the Treasury.

SILVER PRODUCTION OF THE WORLD, 1856–1918

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860 .	4,534,950	1884....	2,788,727	1896.....	5,496,173	1908.....	6,612,304
1861–1865 .	5,505,575	1885....	2,993,805	1897.....	5,663,304	1909.....	7,069,656
1866–1870 .	6,695,425	1886....	2,902,471	1898.....	5,575,336	1910.....	7,471,663
1871–1875 .	9,847,125	1887....	2,990,398	1899.....	5,529,024	1911.....	7,906,446
1876.....	2,323,729	1888....	3,385,606	1900.....	5,599,216	1912.....	7,804,516
1877.....	2,388,612	1889....	3,901,809	1901.....	5,438,443	1913.....	6,964,361
1878.....	2,551,364	1890....	4,180,532	1902.....	5,121,469	1914.....	4,995,951
1879.....	2,507,507	1891....	4,479,649	1903.....	5,386,044	1915.....	5,767,844
1880.....	2,499,998	1892....	4,985,855	1904.....	5,669,124	1916.....	5,246,859
1881.....	2,592,639	1893....	5,339,746	1905.....	5,638,183	1917.....	5,369,627
1882.....	2,769,065	1894....	5,205,065	1906.....	5,683,947	1918.....	(e)5,519,000
1883.....	2,746,123	1895....	5,667,691	1907.....	5,704,083		

(e) Estimated. 1 kilogram = 32.15 Troy ounces.

The Silver Bill passed the Senate on April 18, the House on the 22d, and was signed by the President on the 23d.

Comment on the bill by the four principal bullion brokers in London—Samuel Montagu & Co., Mocatta & Goldsmid, Pixley & Abell, and Sharps & Wilkins—as stated in the "Financial Times," is briefly as follows: (1) "The most important event that has occurred in the silver market for some time past;" (2) "That the release of so much silver should be treated as a 'bull' point strikes one as an anomaly, and it would be so were it not for the fact that the bill is to provide for the gradual repurchase by the American Government of this silver at about $1 per oz., which, of course, is considerably higher than any price ruling for some

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time, and the anticipation of this naturally stiffens the backs of sellers and encourages them to hold off;" (3) "The addition of silver made available should be sufficient to meet all requirements for some time;" (4) "More buying in London has been induced."

SILVER PRODUCTION OF THE WORLD, BY COUNTRIES
(In Troy Ounces, Fine Silver)

	1915.	1916.	1917.	1918.[1]
United States	74,961,075	74,414,800	71,740,000	67,879,206
Canada	28,401,503	25,459,700	22,151,000	21,284,600
Mexico	39,570,151	22,838,400	31,214,000	40,000,000
Central America	2,920,496	2,602,500	2,369,500	2,300,000
South America	13,687,464	15,580,300	15,542,700	16,000,000
Total America	159,540,689	140,695,700	143,017,600	147,460,806
British India	284,875	280,000	275,000	270,000
Burma	285,112	977,121	1,793,659	1,970,503
Japan and Chosen	5,148,404	5,878,400	6,922,500	6,600,000
China and others	19,286	31,000	64,400	70,000
Dutch East Indies	450,000	450,000	450,000	450,000
Total Asia	6,187,777	7,616,521	9,505,550	9,360,503
Transvaal	996,379	968,900	950,000	900,000
Rhodesia	185,233	200,700	212,000	200,000
Congo and other Africa	6,427	33,400	32,000	32,000
Total Africa	1,188,039	1,203,000	1,194,000	1,132,000
Spain and other Europe	9,276,930	8,477,800	8,123,000	8,500,000
Australasia	9,250,000	10,700,000	10,800,000	11,000,000
Total output in ounces	185,443,335	168,693,021	172,640,159	177,453,309
Total value in dollars	92,138,249	110,763,837	138,934,217	171,721,567
Average price in cents	49.684	65.661	81.427	96.772

Figures for foreign countries are based largely on the statistics collected by the United States Mint where no direct official figures can be obtained.
[1] Estimated.

Discussing the future of silver, the Boston News Bureau considers the price stabilized but not fixed at $1 per ounce. While the Pittman silver bill is popularly supposed to fix the price at $1, the question has been raised whether this is not a minimum, and that no limits have been placed on a maximum price. The law as passed does not commandeer the output of silver, neither is there anything in the law or any agreement between the silver producers and the Government that the mining companies shall sell to domestic consumers at the same price as to the Government. In this respect the silver situation is different from steel and copper. Officials of silver-producing companies say that no agreement has been made whereby their entire output or any specific proportion of their output is to be turned over to the Government. The Pittman bill enables the Government almost immediately to come into possession of 350,000,000 silver dollars, and while these may be melted and exported as fast as silver certificates can be withdrawn, and the dollars so melted are to be replaced, there is no time limit placed on the re-coinage.

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Costs of producing silver are well illustrated by the following:

During 10 years the Crown-Reserve Mining Co. at Cobalt, Ontario, produced nearly 20,000,000 oz. of silver at the following cost:

Year.	Production, Ounces.	Price Received, Cents.	Cost per Oz., Cents.
1908	1,798,954	50.64	7.50
1909	4,034,325	51.56	10.31
1910	3,248,196	54.10	11.97
1911	3,430,902	53.46	10.67
1912	2,714,766	62.32	14.02
1913	1,766,678	59.45	23.02
1914	1,425,320	51.92	28.95
1915	657,395	52.40	45.01
1916	274,470	70.40	69.30
1917	329,670	80.63	55.60
Total and averages	19,690,676	55.22	16.40

In discussing whether dollar silver would increase production, it has been pointed out that as 75 per cent. of the metal[1] is a by-product of copper, lead, and zinc, any increase in output depended on the market for these metals, the capacity of smelters, and the attitude of smelter-men.

AVERAGE PRICE OF SILVER IN NEW YORK, 1865–1918
(In cents per fine ounce)

Year.		Year.		Year.		Year.		Year.	
1865	$1.337	1875	$1.24	1885	$1.07	1895	$0.65	1905	$0.604
1866	1.339	1876	1.16	1886	0.99	1896	0.68	1906	0.668
1867	1.330	1877	1.20	1887	0.98	1897	0.60	1907	0.653
1868	1.326	1878	1.15	1888	0.94	1898	0.59	1908	0.529
1869	1.325	1879	1.12	1889	0.94	1899	0.60	.....	.....
1870	1.328	1880	1.15	1890	1.05	1900	0.62	.....	.....
1871	1.325	1881	1.13	1891	0.99	1901	0.60	.....	.....
1872	1.322	1882	1.14	1892	0.87	1902	0.53	.....	.....
1873	1.297	1883	1.11	1893	0.78	1903	0.54	.....	.....
1874	1.278	1884	1.11	1894	0.63	1904	0.58	.....	.....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1909	51.750	51.472	50.468	51.428	52.905	52.538	51.043	51.125	51.440	50.923	50.703	52.226	51.502
1910	52.375	51.534	51.454	53.221	53.870	53.462	54.150	52.912	53.295	55.490	55.635	54.428	53.486
1911	53.795	52.222	52.745	53.325	53.308	53.043	52.630	52.171	52.440	53.340	55.719	54.905	53.304
1912	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	72.792	63.365	60.535
1913	62.938	61.646	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791
1914	57.572	57.502	58.067	58.519	58.175	56.471	54.678	54.344	53.290	50.654	49.062	49.375	54.811
1915	48.855	48.477	50.241	50.250	49.915	49.034	47.519	47.163	48.680	49.385	51.714	54.971	49.684
1916	56.775	56.755	57.935	64.415	74.269	65.024	62.940	66.063	68.515	67.855	71.604	75.765	65.661
1917	75.630	77.585	73.861	73.875	74.745	76.971	79.010	85.407	100.740	87.332	85.891	85.969	81.417
1918	88.702	85.716	88.062	95.346	99.505	99.500	99.625	100.292	101.125	101.125	101.125	101.125	96.772

[1] *Met. Chem. Eng.*, **18**, 435 (1918).

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AVERAGE PRICE OF BAR SILVER IN LONDON
(In pence per standard ounce, 925 fine)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1840.	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841.	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842.	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900
1843.	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250	1903	24.7500
1844.	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375	1904	26.3990
1845.	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750	1905	27.8390
1846.	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500	1906	30.8680
1847.	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625	1907	30.1880
1848.	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375	.....	.....
1849.	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375	.....	.....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1908....	25.738	25.855	25.570	25.133	24.377	24.760	24.514	23.858	23.877	23.725	22.933	22.493	24.402
1909....	23.843	23.706	23.227	23.708	24.343	24.166	23.519	23.588	23.743	23.502	23.351	24.030	23.706
1910....	24.154	23.794	23.690	24.483	24.797	24.651	25.034	24.428	24.567	25.596	25.680	25.160	24.670
1911 ...	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912....	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913....	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573
1914....	26.553	26.573	26.788	26.958	26.704	25.948	25.219	25.979	24.260	23.199	22.703	22.900	25.313
1915....	22.731	22.753	23.708	23.709	23.570	23.267	22.597	22.780	23.591	23.925	25.094	26.373	23.675
1916....	26.960	26.975	27.597	30.662	35.477	31.060	30.000	31.498	32.584	32.361	34.192	36.410	31.315
1917....	36.682	37.742	36.410	36.963	37.940	39.065	40.110	43.418	50.920	44.324	43.584	43.052	40.853
1918....	44.356	42.792	43.260	47.215	48.980	48.875	48.813	49.077	49.500	49.500	48.969	48.492	47.516

According to Edward Brush,[1] vice-president, American Smelting & Refining Co., it is more than usually difficult to estimate the production of silver during 1918, for the reason that the statistical reports as to the commerce of the United States include considerable quantities of coin imported and very large quantities of silver bars exported. These bars were derived from the melting of dollars held in the Treasury of the United States, and represented by silver certificates in circulation. These statistics prove nothing, therefore, as to the production of silver from the mines of this country or of such countries as largely export their silver product to the United States.

The normal effect of an increased value would be to increase production. The average New York quotation for bar silver during the year 1917 was 81.4 cts. per oz., and for the year 1918 approximately 96.8 cts. Here again the normal deductions cannot be depended upon, as the well-known increase in cost of production undoubtedly more than offsets the effect of the increase in value. We must not fail, also, to consider that the value of lead and copper has nearly as great an effect on production as that of silver itself.

The value of the imports of silver into the United States for 1917 is reported as $53,340,477, whereas for 1918 it is $71,375,699, of which $51,017,055 was received from Mexico, or approximately 50,000,000

[1] *Eng. Min. Jour.*, **107**, 41 (1919).

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ounces. The Director of the Mint reports the silver production of Mexico for 1916 as 22,838,400 ounces and for 1917 as 31,214,000 ounces. Both of these amounts are much below the yearly production previous to the Madero administration, the cause being the unsettled condition of the country. It is well known that many mines in Mexico, which had not produced or had produced only to a minor extent during 1917, were able to produce during 1918. But these facts will hardly account for an increased production from 31,000,000 to 50,000,000 ounces. Mexico, however, has been denuded of her silver circulation, except that of the minor coins, and many pesos have been imported and are included in the imported values quoted above. If we assume that, of the increased importations, approximately one-half were pesos, it would seem safe to estimate the production of Mexico for 1918 as 40,000,000 ounces.

Mr. Brush also expresses the opinion that as the Director of the Mint is compelled to purchase at $1 per oz. all the silver which is offered to him, and as only the surplus not needed for coinage or commercial purposes can be offered, it does not seem probable that the Director will be likely to complete the purchase of 200,000,000 oz. for many years to come.

Another factor which may have even a greater effect on silver prices, and consequently on silver production, than all that has happened during the year 1918, is whether the free distribution of gold throughout the world will again be permitted. The gold production of the world is very largely in the hands of the United States and Great Britain and her colonies. Both nations are creditor nations, and, therefore, able to restrict the exportation of gold. The exigency of war has brought home to every one the fact that at least there has been no surplus of gold in the world. With the greatly increased international business which is expected to be done in the coming years by these two leading countries, is there not going to be a continued shortage of the yellow metal, especially in connection with its decreased production? The greatest absorber of the world's production of gold has been India. In the article on Silver in the *Engineering and Mining Journal* of Jan. 12, 1918, it was mentioned that India had imported, previous to the war, $150,000,000 yearly in gold, leaving only a similar amount of new production for the coinage and bank reserves of the whole world. Will Great Britain permit this condition to prevail again? It hardly seems probable. But if she does not, then silver must be substituted if it can be found or produced.

The use of silver for subsidiary coinage is also likely to increase largely. Gold has completely left many countries, and it is not probable that it can be restored to circulation for many years. At the same time, the paper currency has been greatly increased, and silver will be required as a basis. This plan will be much more conservative on account of the

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fact that the price of silver is fixed by the act of Apr. 23, 1918, than would have been the case previous to the war. With the possibility of gold being withheld from India, a conservative estimate as to the yearly demands for silver is shown in the accompanying table.

YEARLY DEMAND FOR SILVER

	Ounces.
For India	150,000,000
For Africa	25,000,000
For the arts	75,000,000
For subsidiary coinage	60,000,000
For China, etc	40,000,000
Total	350,000,000
Production	180,000,000
Shortage	170,000,000

There seems to be abundant room for an increased production, which can be brought about only by an increased price.

The following on the silver market factors in 1918 and future is an abstract from the Annual Bullion Letter of Samuel Montagu & Co., of London:

The position of the silver market at the beginning of 1918 was overshadowed by difficulties connected with the Indian currency. The prospects of any amelioration in then existing conditions were remote, and each return of the Indian currency showed a shrinkage in the holding of coined rupees, despite the volume of silver continually imported on account of the Mint. Events pointed toward the assumption of Government control in some form or other over the distribution and disposal of production—a comparatively easy measure to enforce in view of the large proportion of the world's supplies that is derived from America.

The quotation on the first working day—Jan. 2—was 43½ pence, as it had been on the concluding day of 1917. Owing doubtless to the approach of the Chinese New Year (due on Feb. 11), supplies were scanty, and an advance soon began which by Jan. 5 had carried the quotation to 45⅛d., at which figure it remained until the middle of the month. From this point a decline set in, which, without a reaction, carried the price to 42½d. on Feb. 22. It remained at this figure until Mar. 8. During the whole period, a constant inquiry was maintained from Holland and France, mostly on account of coinage.

By this time the stock of coined rupees in the Indian currency reserve had reached a low ebb. On Mar. 7 the total was returned as 1271 lacs (1 lac = $32,000), against 1905 on the eve of the year. Within the next month, the total fell to 1044 lacs, the low-water mark, not only for 1918, but also for eight years past. The issue of 1- and 2½-rupee notes (introduced last year with a view to easing the situation), did not make much impression. On Feb. 15, for instance, not more than 5 per cent. of the total note issue was represented by notes below five rupees.

Attempts were made to induce Mexico to release a portion of its output, hitherto retained for local coinage. With this end, the United States Government undertook to furnish Mexico with £1,000,000 in gold on condition that the latter relaxed its restrictions upon the export of silver. This, however, was only palliative in effect. The situation was aggravated by the firmness of the Chinese exchanges, with a corresponding demand for silver.

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In these circumstances, some drastic action in America became necessary in order to cope with the keen coinage demand from India, evidenced by the drain of coined rupees from Indian currency reserves, and to minimize the efforts of China to replenish its silver stocks up-country, seriously depleted by the heavy shipments previously made to India. The United States, owing to the difficulty in obtaining remittances to India, had a direct interest in easing the situation. Hence it was decided to introduce a bill into Congress authorizing the realization of some portion of the reserve of 460,000,000 silver dollars, held by the United States Treasury as security for silver certificates to that value.

Meanwhile the price began to rise rapidly, accelerated doubtless by rumors as to the precise nature of the action which the American Government was likely to adopt. Impelled by such considerations, the quotation reached 46d. on Mar. 23. After remaining for a fortnight between that figure and 45¼d., the quotation again hardened, moving sharply, on Apr. 11, from the last-named figure to 46¼d.

The announcement that a bill was being introduced into the United States Senate, providing for the melting and sale of silver dollars above-mentioned, coincided with an announcement by the Indian Council that its drawing rate would be raised one penny—that is to say, from 1s.5d. to 1s.6d. (34 to 36 cts.) per rupee for telegraphic transfers, and for other descriptions of drawing in proportion. At the minimum rate at which the United States Government ultimately received power to sell the melted dollars, namely, $1 per fine ounce, and at the rate of exchange then obtaining between Great Britain and the United States, the cost of providing the silver contents of a rupee worked out at 1s.5.335d. (34.67 cts.), to which shipping expenses, etc., from the United States to India had to be added.

As a consequence of Government action, the price of silver in America rose to about $1 per ounce. The quotation in this country (England) followed suit, and 49¼d. was fixed on Apr. 24. Since that date fluctuations have been slight, never exceeding 1 3/16d. below and ¼d. above. The price of silver practically became stabilized, and subsequent fluctuations represented little more than alterations in the cost of transit (war risk, insurance, etc.) from America to London.

The supply of silver coin in the United Kingdom gradually became deficient, partly owing to the unsettled political condition of Ireland. Considerable consignments of newly minted and other silver coin were sent to that island in order to provide currency in lieu of coin set aside in hoards. As a consequence, a Defence of the Realm regulation, published on May 21, made it illegal for a person to retain current silver coins in excess of the amount reasonably required for his domestic and business concerns. Further, it was made an offence to sell or purchase, or offer to do so, any current coin in excess of its face value.

Owing to the regulation forbidding shipment of silver without a license, and to the extreme difficulty of obtaining the necessary permission, neutral countries were in great straits to provide this metal either for coinage or industry. Indeed, so great did the scarcity become, that it was reported that in Holland current silver coin was being melted down in order to keep manufactories at work.

In the early part of June, the China exchanges developed great firmness, and in the next month this country acquired eagerly such American supplies as came into the open market. In consequence of the competition thus evoked, the export of silver from America, except under license, was officially forbidden. Whereupon export eventually came to a standstill, and the Shanghai exchange was quoted considerably above the parity of silver.

A Treasury Order dated Aug. 9, 1918, published on the 13th, fixed the minimum price for silver in the United Kingdom at 48 13/16d. per standard ounce, at which

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figure it had remained since July 2. After having been quoted at 48 13/16 for 42 successive working days, the maximum price was raised to 49½d. on Aug. 21. This movement was caused by the fixation of an official minimum of 101½ cts. per ounce in the United States. As the demand was constant and active, the London quotation naturally rose at once to correspond.

The rise in the Chinese exchanges having been so pronounced as to cause grave embarrassment to trade with that country, and there being no check to the figure to which they could advance, now that it had become impossible to obtain imports of silver, the Chinese Government decided to conserve the stock in that country by forbidding exports. This ameliorated the situation.

The fixing of official maxima in the United Kingdom and in the United States of America naturally deprived the market of animation, though trade demand in this country was well sustained, stimulated by the impracticability of securing sufficient gold for jewelry and like purposes. On Sept. 11 the American gold and silver administrator met silver dealers in New York and obtained a promise that they would confine the supply to their old customers, and only to an extent of not more than 75 per cent. of their former requirements.

The French Commission on the stability of exchange asserted as follows: "The early establishment and permanent security of the gold exchange standard in countries now upon the silver standard would be materially aided by stability in the price of silver bullion. Stability in the price of silver bullion would be promoted by reasonable regularity in the purchase of silver required by each Government for actual coinage purposes." Any combination of nations, to ensure more or less continuous purchases of silver for the purpose of coinage, could hardly fail to draw India, the chief silver-using country, within its orbit.

The coinage of silver at the Indian Mints during the fiscal year 1917–18 amounted to 23,87,07,287 rupees, compared with 30,77,07,326 rupees during the preceding financial year.

With the exception of 1,26,76,902 rupees re-coined from uncurrent and withdrawn coin, the silver was provided from purchases. The amount thus acquired and applied was therefore about 77,500,000 fine ounces.

In October, unsatisfactory climatic conditions caused a cessation of demand for Indian remittances and induced the India Council to offer sterling drafts on London to the extent of £1,000,000 a week. The all-important place in the destiny of India occupied by the monsoon, which has been described as the jugular vein of Indian trade, was thus again demonstrated. In normal times the reversal of the flow of remittances would have been reflected in the price of silver. Such, however, has been, and is still likely to be, the need for Indian metallic currency, that this check, possibly temporary, to the steady advance of Indian prosperity does not as yet relieve the Indian Government from feeding its mints with fresh purchases of silver.

Although the India Council eventually raised the amount of sterling drafts on London offered in India for disposal by tender to £2,000,000 a week, the Indian note issue continued to increase, and the demand for metallic currency showed no sign of abatement. Therefore, while Government restrictions upon the export of certain goods were removed, owing to the great change in the aspect of military affairs, silver remained under a ban, except for articles manufactured wholly or partly of the metal. In America, about 2,000,000 oz. purchased for China some months back, but licenses for which were refused, was released for export, and was shipped from San Francisco.

The signature of the armistice, which brought hostilities to an end on Nov. 11, had some effect upon the silver market. The quotation had remained at 49½d. for 71 successive working days—a record duration in living memory—but the withdrawal of

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submarine activity at once reduced the rates of war-risk insurance. This substantially lowered the cost of bringing silver from America, and on Nov. 12 the price fell ¾d. to 48¾d. (the new official maximum). Much variation cannot be expected so long as the value of silver in New York is maintained about $1 per ounce. The cost of insurance from America having been reduced to an almost normal figure, the quotation was lowered to 48 7/16d. on Dec. 6, after remaining at 48¾d. for 21 working days. The official maximum was also reduced to 48 7/16. Notwithstanding this reduction, the closing quotation exceeded the average for the year.

The return of erstwhile soldiers and war-workers to peaceful occupations will afford more labor for the mining industry, and, in so doing, increase the output of silver. Mexico, that great reservoir of precious metal, is setting her house in order, and will substantially swell the total. The hope that the high price of silver may be sustained cannot fail to stimulate new mines and reopen many that had ceased to be payable at pre-war rates.

As long as the United States Government is pledged to re-purchase at $1 per oz. the bullion, composed of melted United States coin, which it placed at the disposal of the Indian Mint (at present amounting to 115,000,000 oz.), the price cannot fall much, if at all, below 46d. (allowing for the return of the American exchange to a normal figure). If there were external competition with the United States Government, the re-purchase of this bullion, together with local trade requirements, would absorb probably two years' production of that country.

Trade all over the world has felt the lack of silver; hence a good and continuous demand may be expected from many quarters. As to coinage demand generally, no positive views can be expressed, for currency arrangements are now in a state of flux, rendering future policy as to the precious metals uncertain. In view of the shortage of gold that may prevail for many years to come, large supplies of silver for currency reserves may be considered desirable in other quarters. It must not be forgotten that many millions of silver medals will be struck.

Indian coinage operations will depend on the harvests. As gold may be scarce for some years, the onus of supplying India with currency will fall upon silver. Should unfavorable conditions (such as recently have obtained) continue, there may eventually ensue a redundancy of silver coin in India. At the present sterling value of the rupee (1s. 6d.), full-weight rupees would be worth about 48½d. per oz. standard (exclusive of cost of bringing to market here in a marketable condition). Similarly if the sterling value of the rupee reverted to 1s. 4d., the worth would be about 43d. per oz. standard.

The deduction from the preceding remarks is that, although output may be accelerated, the needs of India and China, the obligation of the United States Government to re-purchase, and the accumulated demand for the trade, will ensure a high level of prices for some time.

SILVER MOVEMENTS IN 1918

The following tables of imports and exports of silver are from the Monthly Summary of foreign commerce of the United States, issued by the Department of Commerce at Washington:

Imports.		Exports.	
Year.	Value.	Year.	Value.
1915	$34,483,954	1915	$53,598,884
1916	32,263,289	1916	70,595,037
1917	53,340,477	1917	84,130,876
1918	71,375,699	1918	252,846,464

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Country.	Imports from		Exports to	
	1917.	1918.	1917.	1918.
France	$5,817	$193,945	$22,226	$5,059,922
United Kingdom	164,646	142,104	28,011,099	32,687,841
Canada	7,100,557	7,641,496	2,608,146	3,606,561
Central America	2,753,285	3,033,759	.....	.....
Mexico	31,986,188	51,017,055	2,067,132	2,792,086
West Indies	356,443	278,492	45,510	91,765
Brazil	6,615	3,987	.....	.....
Chile	1,508,848	2,160,575	.....	.....
Colombia	225,381	210,327	.....	.....
Peru	7,214,747	5,115,577	.....	.....
Venezuela	2,981	1,019	.....	.....
China	10,750	.....	12,106,631	23,786,077
East Indies	1,713,117	248,223	.....	.....
Argentina	.....	.....	8,695	178,621
India	.....	.....	24,392,403	163,154,135
Hongkong	.....	.....	8,612,757	19,322,299
Other countries	291,102	1,329,140	6,256,277	2,167,157
	$53,340,477	$71,375,699	$84,130,876	$252,846,464

Gold and Silver Mining in the United States

The following tables show the production of precious metals from 1880 to 1918:

GOLD

Year.	Ounces.	Value.	Year.	Ounces.	Value.	Year.	Ounces.	Value.
1880	1,741,500	$36,000,000	1893	1,739,323	$35,955,000	1906	4,565,333	$94,373,800
1881	1,678,612	34,700,000	1894	1,910,813	39,500,000	1907	4,374,827	90,435,700
1882	1,572,187	32,500,000	1895	2,254,780	46,610,000	1908	4,574,340	94,560,000
1883	1,451,250	30,000,000	1896	2,568,132	53,088,000	1909	4,821,701	99,673,400
1884	1,489,950	30,800,000	1897	2,774,935	57,363,000	1910	4,657,018	96,269,100
1885	1,538,373	31,801,000	1898	3,118,398	64,463,000	1911	4,687,053	96,890,000
1886	1,686,788	34,869,000	1899	3,437,210	71,053,400	1912	4,520,717	93,451,500
1887	1,603,049	33,136,000	1900	3,829,897	79,191,000	1913	4,299,783	88,884,400
1888	1,604,478	33,167,500	1901	3,805,500	78,666,700	1914	4,572,976	94,531,800
1889	1,594,775	32,967,000	1902	3,870,000	80,000,000	1915	4,887,602	101,035,700
1890	1,588,877	32,845,000	1903	3,560,000	73,591,700	1916	4,479,051	92,590,300
1891	1,604,840	33,175,000	1904	3,892,480	80,464,700	1917	4,051,440	83,750,700
1892	1,597,098	33,015,000	1905	4,265,742	88,180,700	1918	3,313,000	68,493,500[1]

[1] Preliminary estimate.

SILVER

Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.
1880	30,318,700	$34,717,000	1893	60,000,000	$46,800,000	1906	56,517,900	$38,256,400
1881	33,257,800	37,657,500	1894	49,500,000	31,422,100	1907	56,514,700	37,299,700
1882	36,196,900	41,105,900	1895	55,727,000	36,445,500	1908	52,440,800	28,050,600
1883	35,732,800	39,618,400	1896	58,834,800	39,654,600	1909	54,721,500	28,455,200
1884	37,743,800	41,921,300	1897	53,860,000	32,316,000	1910	57,137,900	30,854,500
1885	39,909,400	42,503,500	1898	54,438,000	32,118,400	1911	60,399,400	32,615,700
1886	39,694,000	39,482,400	1899	54,764,500	32,858,700	1912	63,766,800	39,197,500
1887	41,721,600	40,887,200	1900	57,647,000	35,741,100	1913	66,801,500	40,348,100
1888	45,792,700	43,045,100	1901	55,214,000	33,128,400	1914	72,455,100	40,067,700
1889	50,094,500	46,838,400	1902	55,500,000	29,415,000	1915	74,961,075	37,397,300
1890	54,516,300	57,242,100	1903	54,300,000	29,322,000	1916	74,414,800	51,083,528
1891	58,330,000	57,630,000	1904	57,682,800	33,456,000	1917	71,740,400	64,225,593
1892	63,500,000	55,662,500	1905	56,101,600	34,222,000	1918	67,879,200	65,688,059[1]

[1] Preliminary estimate.

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PRODUCTION OF GOLD IN THE UNITED STATES, BY STATES (a)

States.	1915.		1916.		1917.		1918.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)
Alabama	247	$5,100	358	$7,400	106	$2,200	36	$700
Alaska	808,346	16,710,000	780,037	16,124,800	709,7?9	14,671,400	440,622	9,108,500
Arizona	220 392	4,555,900	197,989	4,092,800	250,613	5,180,600	278,647	5,760,200
California	1,090,731	22,547,400	1,063,302	21,980,400	1,012,461	20,929,400	842,389	17,207,000
Colorado	1,089,928	22,530,800	928,075	19,185,000	772,766	15,974,500	621,791	12,853,500
Georgia	1,684	34,800	987	20,400	314	6,500	169	3,500
Idaho	56,628	1,170,600	51,195	1,058,300	36,511	754,800	30,764	636,000
Missouri	.....	.....	.....	.....	15	300	10	200
Montana	240,825	4,978,300	209,386	4,328,400	177,690	3,673,200	153,375	3,170,600
Nevada	574,874	11,883,700	438,505	9,064,700	335,361	6,932,500	322,276	6,662,000
New Mexico	70,632	1,460,100	65,306	1,350,000	52,505	1,085,400	30,871	638,200
North Carolina	8,258	170,700	1,113	23,000	524	10,800	38	800
Oregon	90,321	1,867,100	91,985	1,901,500	81,624	1,687,300	60,951	1,260,000
South Carolina	174	3,600	15	300	82	1,700	.....	.....
South Dakota	358,145	7,403,500	361,444	7,471,700	356,662	7,372,900	328,305	6,786,700
Tennessee	329	6,800	276	5,700	267	5,500	263	5,400
Texas	87	1,800	24	500	5	100	5	100
Utah	189,045	3,907,900	186,679	3,859,000	170,353	3,522,100	152,018	3,142,500
Vermont	.....	.....	14	300	5	100	47	800
Virginia	24	500	24	500	63	1,300	20	400
Washington	22,330	461,600	28,087	580,600	23,617	488,200	16,556	342,300
Wyoming	672	13,900	977	20,200	179	3,700	18	400
Total	4,825,311	$99,748,000	4,405,778	$91,075,500	3,981,482	$82,304,500	3,269,171	$67,579,800
Porto Rico	34	700	29	600	5	100	.....	.....
Philippine Islands	63,898	1,320,900	73,249	1,514,200	69,953	1,446,100	44,202	913,700
Total	4,887,604	$101,035,700	4,479,056	$92,590,300	4,051,440	$83,750,700	3,313,373	$68,493,500

(a) The statistics in this table are reported by the Director of the Mint, those for 1918 being the preliminary figures. (b) At $20.67 per oz.

SILVER PRODUCTION OF THE UNITED STATES, BY STATES (a)

	1916.		1917.		1918.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (c)	Fine Ounces.	Value. (d)
Alaska	1,266,317	$833,000	1,207,164	$994,100	796,836	$796,836
Arizona	6,680,252	4,394,600	6,962,257	5,733,400	6,771,490	6,771,490
California	1,936,910	1,274,200	2,107,107	1,735,200	1,555,417	1,555,417
Colorado	7,551,761	4,967,900	7,291,495	6,004,500	6,982,313	6,982,313
Georgia	.....	.....	.....	.....	43	43
Idaho	11,570,399	7,611,500	11,402,542	9,390,000	10,188,056	10,188,056
Illinois	5,782	3,800	7,116	5,900	8,939	8,939
Maryland	153	100	538	400	164	164
Michigan	759,068	499,300	684,225	563,400	491,939	491,939
Missouri	128,860	84,800	63,344	52,200	40,948	40,948
Montana	14,046,054	9,240,100	14,555,034	11,986,100	15,341,793	15,341,793
Nevada	13,682,067	9,000,600	11,217,654	9,237,700	10,113,405	10,113,405
New Hampshire	935	600	.....	.....	.....	.....
New Mexico	1,729,917	1,138,000	1,535,807	1,264,700	763,758	763,758
North Carolina	1,738	1,100	590	500	9	9
Oklahoma	606	400	.....	.....	.....	.....
Oregon	221,887	146,000	172,152	141,800	150,207	150,207
Philippine Islands	17,643	11,600	12,715	10,500	12,597	12,597
South Dakota	210,100	138,200	190,382	156,800	165,865	165,865
Tennessee	93,837	61,700	106,975	88,100	131,931	131,931
Texas	664,319	437,000	587,945	484,200	612,436	612,436
Utah	13,545,802	8,911,000	13,360,905	11,002,700	13,439,811	13,439,811
Vermont	1,964	1,300	403	300	5,117	5,117
Virginia	508	300	4,500	3,700	2,967	2,967
Washington	294,516	193,700	266,112	219,100	302,406	302,406
Wyoming	3,407	2,200	3,400	2,800	719	719
Total	74,414,802	$48,953,000	71,740,362	$59,078,100	67,879,206	$67,879,206

(a) Figures of the Bureau of the Mint and the U. S. Geological Survey, those for 1918 being a preliminary estimate. (b) At $0.658 per oz. (c) At $0.824 per oz. (d) At $1 per oz.

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Conditions affecting gold and silver mining during 1917 continued in 1918, but with accentuated force, resulting in large decreases in production. Shortage of labor, inefficient labor, cost of supplies, difficulty in securing supplies, and the lower purchasing power of gold, all tended toward either a curtailment of operations or shut-down. Silver mines had every inducement to enlarge outputs, owing to the fixed price of their product, yet some of the properties reported smaller yields due to lower-grade ore being treated. About 70 per cent. of the silver output is a by-product of copper and lead smelters, and while copper production showed a small increase, that of lead was a decrease as compared with 1917, the latter evidently accounting for some of the falling-off of silver. In the following state reviews, the U. S. Geological Survey's officers are mentioned where the matter is abstracted from their annual reports.

Alaska.—Production during the past 15 years is as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1904	443,115	$9,160,000	198,700	$114,934
1905	756,101	15,630,000	132,174	80,165
1906	1,066,030	22,036,794	203,500	136,345
1907	936,043	19,349,743	149,784	98,857
1908	933,290	19,292,818	135,672	71,906
1909	987,417	20,411,716	147,950	76,934
1910	780,131	16,126,749	157,850	85,239
1911	815,276	16,853,256	460,231	243,923
1912	829,435	17,145,951	515,186	316,839
1913	755,947	15,626,813	362,563	218,988
1914	762,596	15,764,259	394,805	218,327
1915	807,966	16,702,144	1,071,782	543,393
1916	780,037	16,124,800	1,266,317	833,000
1917	733,911	15,171,300	1,351,100	1,099,800
1918[1]	480,000	10,000,000	870,000	870,000[1]

[1] Preliminary estimate.

The yield of gold last year was the smallest since 1904, according to G. C. Martin, due in general to shortage of labor, cost of supplies, and low returns from the mines at Juneau. The value of the placer gold in 1918 was about $6,100,000, derived by regions as follows: Yukon basin, $4,325,000; Seward Peninsula, $1,140,000; Copper River, $300,000; Cook Inlet—Susitna region, $215,000; Kuskokwin region, $90,000; miscellaneous, $30,000. The total in 1917 was $9,810,000. The decrease in 1918 was general throughout the Territory, except in the Chistochina district, where there was a 50-per cent. increase, and in the upper Yukon districts, where there may have been a slight increase. The Nizina gold placers are still being worked on a large scale. The Chistochina placer mines are said to have had a very successful season, and to have made an unusually large production.

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The placers of the Yukon basin in Alaska produced $4,325,000. This is a decrease of more than $2,000,000 from the production of 1917, and is the smallest production since 1904. The decrease was general throughout the region, except in the Circle district. The output of the principal districts was as follows:

Iditarod, $1,300,000 (decrease of $200,000); Tolovana, $870,000 (decrease of $280,000); Fairbanks, $800,000 (decrease of $500,000); Ruby, $400,000 (about half of 1917); Marshall, $200,000; Circle, $200,000; Hot Springs, $150,000; and Koyukuk, $125,000 (half of 1917). All of these regions will benefit greatly when the Government railroad is completed in 1920.

The value of the mineral production of Seward Peninsula in 1918 was $1,210,000, compared with $2,747,000 in 1917. Of the output in 1918, $1,140,000 represents the value of the placer gold and $70,000 the value of the miscellaneous products, including tin, tungsten, silver, and platinum. By districts the yields were:

Nome, $455,000; Solomon, $62,000; Council, $293,000; Fairhaven, $118,000; Koyuk, $145,000; Kougarok, $60,000; and Port Clarence, $7000. Twenty dredges were operated, also 28 underground mines, 24 hydraulic mines, and 55 open-cut mines, other than hydraulic.

About 25 gold-lode mines were operated, compared with 31 in 1917. The value of the lode gold mined in 1918 is $3,780,000, compared with $4,580,000 in 1917. There were increases in output at the Ready Bullion and Chichagoff mines, in southeastern Alaska, and in the Willow Creek district. Most of the gold mines on Prince William Sound have suspended operations. The mill and cyanide plant of the North Midas mine, in the Chitina valley, was completed and began operating late in the year. In the Fairbanks district seven small mines operated part of the year, yielding a total output about half as large as in 1917.

The gold-lode mines of the Willow Creek district reported a successful season. The Gold Bullion, Gold Cord, Alaska Free Gold, Mabel, and Talkeetna mines were operated, producing an aggregate amount of gold worth more than $270,000. Development was carried on and a small mill erected at the War Baby mine on Craigie Creek. The Broad Pass mineral belt, 120 miles north of Willow Creek, is on the railroad route, and according to F. LeRoi Thurmond[1] offers good possibilities.

In spite of many difficulties, the Alaska Gastineau continued operations, but at reduced capacity. An operating loss of $96,945 was reported for the year 1918. A perusal of the table below gives the impression that ore was selected during part of 1918, when the labor supply was low.

[1] *Min. Sci. Press*, 118, 57 (1919).

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Month.	1918.		1917.	
	Tons.	Value per Ton.	Tons.	Value per Ton.
January	179,300	$0.903	173,300	$1.240
February	140,305	0.934	150,000	1.350
March	150,093	1.114	217,700	1.090
April	125,435	1.148	212,200	1.090
May	101,200	1.114	227,900	1.787
June	82,600	1.250	202,490	1.102
July	74,830	1.319	166,988	0.985
August	96,250	1.367	179,150	0.994
September	47,850	1.247	177,828	1.064
October	75,870	0.995	191,610	1.069
November	94,395	0.968	175,960	1.080
December	117,310	0.983	165,131	1.036

In the stopes there was estimated to be 2,000,000 tons of broken ore, while above No. 13 level there is 6,323,117 tons of $1.02 ore.

The Alaska Juneau company issued a statement, in which it was said that the new mill will have to be altered to treat the ore successfully, such changes to cost up to $500,000. The plant had treated in 1918 to October a total of 498,861 tons of 86.5-cent ore, recovering 79.5 per cent. at a cost of 63 cts. per ton. In the entire year of 1917 the figures were 672,424 tons, 87.5 cts. per ton, 74 per cent. extraction, and 56.11 cts. per ton. The company's indebtedness is over $1,347,000, and to pay this and make improvements, there is to be raised the sum of $3,500,000 in first-mortgage, 10-year, 7-per cent. gold bonds.

The Alaska-Treadwell group, of which only the Ready Bullion is being worked as the others are flooded, made a final profit of $344,629 in 1917, including the sale of old equipment. During the 9 months ended Sept. 30, 1918, the Ready Bullion mill treated 328,990 tons of ore for gold worth $724,686. The cost was $826,819, including $181,121 for extraordinary development. The Ready Bullion shaft is down 2800 ft., and if pay-ore is found sinking will continue to 3400 feet. Later, connection may be made with the flooded workings. Reserves are estimated at 2,300,000 tons above 2600 ft., of which 1,400,000 tons will be recovered.

Arizona.—Production during the past five years is as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1914	221,020	$4,568,900	4,439,500	$2,455,000
1915	220,392	4,555,900	5,665,672	2,826,500
1916	197,989	4,092,800	6,680,252	4,394,600
1917	267,700	5,533,800	6,962,257	5,754,700
1918	278,647	5,760,000	6,771,490	6,771,490

A large part of Arizona's gold is obtained from the smelting of copper ore, the tonnage of which was increased markedly during the year, but

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nearly half of Arizona's total gold output was due to the cyanidation of gold ores in the Oatman region. The United Eastern remained by far the largest gold producer of the State, and the Tom Reed continued to yield. The Gold Road mine was not productive, and the output of the Copper Chief in the Verde district was much less, according to V. C. Heikes. The United Eastern produced $2,138,417 from 92,339 tons of ore, and paid monthly dividends of 5 cts. per share, equal to $68,150 each. It is probable that the slight decrease in silver resulted from smaller shipments of lead ore, which contains considerable silver. The increase in the copper output came partly from ores which contain little or no silver, such as the New Cornelia, at Ajo.

California.—The past 14 years' records show the following output:

Year.	Gold, Value.	Silver, Oz.
1905	$18,898,545	1,076,174
1906	18,732,452	1,220,641
1907	16,727,928	1,138,858
1908	18,761,559	1,647,278
1909	20,237,870	2,098,253
1910	19,715,440	1,840,085
1911	19,738,908	1,270,445
1912	19,713,478	1,300,136
1913	20,406,958	1,378,399
1914	20,653,496	1,471,859
1915	22,442,296	1,678,756
1916	21,980,400	1,936,910
1917	20,087,504	1,989,800
1918	17,242,400	1,555,417

The decrease in 1918 is less than had been expected, according to C. G. Yale. Conditions existing during 1918 affected the deep mines much more unfavorably than placer mining. The low grade of the ore in the greater mines of the Mother Lode region compels strict economy at all times, and with steadily rising costs in all directions it became impossible for some of them to continue operations except at a loss. As a result, several of these companies discontinued operation and contented themselves with keeping the mines clear of water until conditions might change. Other companies reduced working forces, hung up some of their stamps, and virtually ceased production. Some smaller mines throughout the State followed the lead of the larger corporations, but a great many of these ceased operations entirely for the time being. The cost of producing an ounce of gold, compared with what was received for it, became too great for them to continue. The deep mines of California, to which these statements refer, produce 60 per cent. of the State's output. The remainder is recovered by various forms of placer mining, the most productive of which is dredging. The gold-dredging industry of the State continues to be generally prosperous, although no new extensive fields have been discovered. Nevertheless some smaller fields, notably in the northwestern part of the State, are receiving more attention than

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formerly, and some new and large dredges have been constructed. The dredging industry has not been so materially affected by war conditions as quartz mining, but it has nevertheless been hampered to some extent by lack of supplies and especially by less efficient labor than formerly, and a lessened supply of electric power.

No special change is shown in the drift or surface placer-mining fields. However, there is a marked revival in hydraulic mining after some 30 years of virtual idleness of former large producers. The result of this revival will hardly be apparent in the final figures of gold production for 1918, as most of the new work being done in the rehabilitation of the hydraulic mines is not yet finished; but at a dozen or more places in the older hydraulic-mining regions, in the drainage basins of Sacramento and San Joaquin rivers, heavy new concrete dams are being constructed under plans approved by the California Débris Commission. All this work is being done on old mines which were formerly productive, but were closed 25 or 30 years ago, when the Federal Government ordered the impounding of débris in settling basins behind permanently constructed restraining dams.

Hydraulic-mining débris in the Sierra Nevada was reviewed by G. K. Gilbert,[1] who considered the quantity of débris that had been carried down the rivers to the valleys from the early 50's to the time of the injunctions against hydraulicking in 1884. Much of this silt was deposited in San Francisco Bay. It is estimated that 1,665,000,000 cu. yd. of gravel was moved in California, plus 700,000,000 yd. moved by natural erosion from 1849 to 1914. Surveys indicate the following distribution of the total of 2,365,000,000 yd.: 11 per cent. in the mountains, 21 per cent. in the Yuba River basin, 4 per cent. in channels of valley rivers, 13 per cent. on inundated lands and tidal marshes, 48 per cent. in the bays, and 3 per cent. in the ocean.

The number of mines in the State producing gold was 585 fewer at the end of 1917 than at the end of 1912, which is a loss of 59.7 per cent. In the same period the number of productive quartz mines has fallen off 69 per cent.; hydraulic mines, 49; dredges, 15; drift mines, 63; and surface placers, 55 per cent. The total gold output of 1917, however, shows a 2-per cent. increase over that of 1912. The decrease in the number of productive gold mines in Califoria can not be attributed to war conditions alone.

Silver in this State is derived mainly from copper and lead ores, although an appreciable quantity is also mined with the gold. Owing to the rise in the value of the metal some few old silver mines in the southern part of the State have been reopened, but none on a large scale.

[1] Professional Paper 105, U. S. Geological Survey.

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Reverting to the Mother Lode mines in Amador County it may be said that the general policy is to issue no statements for the press. It is known that the Argonaut is extracting rich ore below 4000 ft. (incline). The Kennedy is now below 3900 ft. (vertical). The Central Eureka, by agreement with the South Eureka, closed indefinitely, has to keep the water down in both mines. Early in the year the Central had little or no ore-reserves, but by persistent exploration had found some fine shoots around the 3500-ft. level in December, making the future much brighter. The Old Eureka company continued exploration of this old mine, going right ahead as if there were no labor shortage or high costs. Developments cited in the Central are of special importance to the Old Eureka adjoining. The shaft is down 2900 ft., and is to be sunk several hundred feet more. Considerable ore has been opened on the 2100-ft. level, also some at 1200 feet. This mine, it should be remembered, was closed for 30 years. The Keystone mine, during the second half of 1918, treated 44,322 tons of $2.52 ore. This mine is 1800 ft. deep. The Plymouth Consolidated paid two dividends last year, totaling $57,600. In October the output was $55,700 from 10,550 tons, of which $15,000 was profit. New work at 2540 ft. is encouraging. During October, underground men in this county received a 50-ct. raise in wages, surface men getting from 25 to 50 cents.

In Calaveras County, the Utica mine at Angels was closed, but the Gold Cliff adjoining continued work. In Tuolumne County, the Belmont Shawmut started its reconstructed mill in May, but closed temporarily on account of economic conditions. The mine is estimated to contain at least 600,000 tons of ore. This property is controlled by the Tonopah Belmont Development Co. of Nevada. The mill at the Harvard was overhauled to use flotation; and the Morgan mine was bought by a strong syndicate in January, 1919.

The largest dredging company in the State is the Yuba Consolidated Gold Fields, operating on the Yuba river. During its financial year ended February 28, 1918, there was recovered gold worth $2,849,220, from 15,468,000 cubic yards of 18.42-ct. gravel. Costs were 4.90 cts. per yard. From March to June, inclusive, 1918, the dredges made a profit of $584,351, the gravel yielding 18.30 cts., costing 6.68 cts. per yard. The Natomas company is operating 8 boats on the American River, east of Sacramento, and two near Oroville. Two of the former are re-soiling ground, returning it to a cultivable condition, while one boat at Oroville is re-working old dredge tailing. This company is making profits, but they are absorbed in paying interest on the land scheme, which now looks more hopeful. During 1918, the dredges dug 27,172,626 cu. yd. of gravel, recovering gold worth $2,008,966, of which $746,119 was

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profit. In 5 years the total yield was $11,517,170, the profit being $5,669,061. About 182,220,000 yd. remain to be dredged.

Colorado.—This State is the second largest gold producer and the fifth in silver. The last 11 years show the following:

Year.	Gold, Oz.	Value.	Silver, Oz.	Value.
1908	1,106,385	$22,871,000	10,150,200	$5,429,400
1909	1,056,829	21,846,000	8,846,300	4,600,100
1910	992,969	20,526,500	8,523,000	4,602,400
1911	925,839	19,138,800	7,331,200	3,958,800
1912	899,222	18,588,562	8,212,070	5,050,423
1913	877,857	18,146,916	9,325,255	5,632,454
1914	961,845	19,883,105	8,796,065	4,864,224
1915	1,084,323	22,414,944	7,027,972	3,563,182
1916	928,075	19,185,000	7,551,761	4,967,900
1917	772,766	15,974,500	7,291,495	6,004,500
1918	621,791	12,853,500[1]	6,982,313	6,982,313[1]

[1] Preliminary estimate.

The greatest year for gold was in 1900, when the total was $28,762,036. Cripple Creek was then yielding large quantities of the metal, that year accounting for $18,073,000. In 1918 this district produced less than half of that quantity, or $8,294,000, equal to 64.5 per cent. of the State's total. Last year's output was in itself a drop of $3,121,000.

According to C. W. Henderson, the decrease in gold from Colorado in 1918 showed in both bullion products and in ore and concentrates marketed directly to lead plants; but there was an increase of silver content in ore marketed direct from the mines, the decrease in silver and lead being due to a decrease in lead concentrates from lead-zinc ores. Lake County, chiefly Leadville, but including also the Lackawanna Gulch, Sugar Loaf, St. Kevin, and Wortman lode districts and the Arkansas River dredge district, produced $879,000 in gold, and 2,348,000 oz. of silver, compared with $1,160,180 in gold, and 2,177,638 oz. of silver in 1917.

In the San Juan region the situation as to labor, mining costs, and influenza was particularly arduous, but despite these difficulties San Juan County's production fell off only $60,000 in gold and 200,000 oz. of silver. San Miguel County mills, treating ore from both San Miguel and Ouray counties, produced $2,180,000 in gold, an increased yield, and 1,170,000 oz. of silver. Ouray County mines, as operated from the Ouray side, showed an increase for all metals, owing to work at Red Mountain and Sneffels. Development work was also continued at the Camp Bird mine, and the long low-level adit was completed during the year. A short shoot of rich ore was found, and raising to the old workings is under way.

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At Cripple Creek the principal event among the 65 companies was closing of the Portland company's mills at Colorado Springs and at Victor, all the low-grade ore being sent to the Independence plant at Cripple Creek. Late in 1918 the Portland opened rich ore on its 21st level. The Vindicator continued operation of its two mines and flotation plant. A fair number of small mines were operated, particularly by lessees. The quantity of ore sent direct to smelters was nearly equal to that of 1917. The Cresson opened another good orebody, and continued sending ore to the Golden Cycle mill at Colorado Springs. A monthly dividend of 10 cts. per share, equal to $122,000 was kept up, and to Jan. 10, 1919, the total paid was $7,271,163. The Roosevelt drainage-tunnel was completed late in December. It is 24,355 ft. long, and during the 11 years of construction cost $812,000, or $33.30 per foot. This expense includes sinking an intermediate shaft 700 feet. A 1720-ft. drift connects with the Cresson and one of 2000 ft. with the Portland mines. A great saving has been made, as not a pump is working in the district, which is effectively drained to a depth of 2113 ft. In 1906 the flow was 17,000 gal. per min.; now it is 2500 gal. per min. Dividends paid totaled $2,380,000—$1,464,000 by the Cresson, $540,000 by the Golden Cycle, $300,000 by the Portland, $60,000 by the Vindicator, and $16,500 by the Granite; also probably $250,000 by lessees and others.

At Telluride in the San Juan region, the Tomboy company is erecting a flotation plant costing $150,000. It is estimated that on the present grade of ore ($7.50 per ton) an extraction of an additional $1 per ton can be made, the total expenditure to be recouped in 12 months.

Mining in the Telluride district was described by H. J. Wolf,[1] who dealt with climatic conditions, ore deposits, and methods of mining, particularly driving tunnels. The commercial ores extracted, carrying chemically combined gold and silver, are galena, argentiferous gray copper, polybasite, proustite, pyrargyrite, and stephanite. Payable ores vary in composition from simple gold-bearing quartz to a complex mixture of lead, zinc, and iron sulphides, carrying small quantities of gold, silver, and copper.

At Alta, 4 miles from Telluride, the Belmont Wagner Mining Co., a subsidiary of the Tonopah Belmont Development Co. of Nevada, is operating 124 claims. Late in 1917 this company took charge, and by mid-1918 had done considerable development and mill reconstruction. Reserves total over 300,000 tons assaying $11 per ton. The ore carries gold, silver, lead, and copper.

Ore treatment in Colorado, accompanied by a map of the State and lists of amalgamation, concentration, cyanidation, and smelting plants,

[1] *Eng. Min. Jour.*, **106**, 395 (1918).

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was briefly covered by the *Engineering and Mining Journal*[1] on the occasion of the meeting of the American Institute of Mining Engineers at Denver and Cripple Creek.

Idaho.—This is an important silver producer, but a small gold producer. The former is a by-product of lead and zinc ores, the latter is almost equally recovered by dredging and from some small gold mines. The yearly outputs for some time past are as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1909	70,329	$1,453,822	7,041,633	$3,661,649
1910	53,060	1,096,842	7,369,742	3,979,661
1911	66,389	1,372,387	8,196,136	4,343,952
1912	66,816	1,381,214	8,294,745	5,101,268
1913	65,043	1,344,559	9,989,193	6,033,473
1914	57,431	1,152,315	12,479,516	6,901,172
1915	57,070	1,179,731	11,769,128	5,966,948
1916	51,195	1,058,300	11,570,399	7,611,500
1917	36,511	754,800	11,402,542	9,390,000
1918	30,764	636,000[1]	10,188,056	10,188,056[1]

[1] Preliminary figures.

The most important gold production came from the Sherman and Corporal property, in Idaho County. Close to this was the output of the Gold Hill and Iowa mines, in Boise County. A considerable output of gold has its source in the copper ore from Mackay, in Custer County. Although the Boston & Idaho dredge at Idaho City was operated for a time during the year, the total gold from dredging operations was considerably decreased, according to C. N. Gerry. The plant of the Kirtley Creek company, in Lemhi County, made only a small production previous to being dismantled, and the dredge at Pierce had only a small output. The new boat on Prichard Creek, near Murray, commenced operations during the year, and should help to maintain the placer output.

According to F. A. Thomson of the School of Mines at Moscow, Idaho, there is in central Idaho a great undeveloped gold-bearing area which will remain locked until adequate means of access are available. There are already a number of developed properties. Nothing but placer mining or bonanza quartz mining can thrive under present conditions. The placers of central Idaho have been exhausted. Lode mining has yielded about $3,000,000. No workings are below 450 feet.

The mine output of silver made an unusual decline of about 12 per cent. Decreases amounting to 400,000 oz. or more were shown by the Hercules, Morning, Greenhill-Cleveland, Caledonia, and Bunker Hill & Sullivan mines. The Consolidated Interstate-Callahan was closed

[1] Vol. 106, p. 387 (1918).

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part of the year for alterations. This mine has a large silver yield. Fortunately the Hecla, Tamarack & Custer, and Gold Hunter made better records. The largest silver producer of the State was the Hercules mine, at Burke, followed by the Hecla mine, nearby, which took second place from the Bunker Hill & Sullivan, now third in rank. Other important silver producers were the Morning, Tamarack & Custer, Gold Hunter, and Caledonia. The mines in the Coeur d'Alene district produced 90 per cent. of the total of the State.

Montana.—This is also a silver rather than a gold state, the former coming from the copper and zinc ores, and the latter from dredges and lode mines. In spite of the larger output of copper in 1918, gold decreased by about $400,000. The following table gives Montana's precious-metal yield for several years:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1908	147,913	$3,057,640	10,356,199	$5,488,785
1909	183,414	3,791,510	12,378,714	6,436,931
1910	180,462	3,730,486	12,162,857	6,567,942
1911	179,499	3,710,571	11,985,196	6,352,154
1912	175,371	3,625,235	12,731,638	7,829,957
1913	168,995	3,493,432	13,819,201	8,346,797
1914	200,446	4,143,600	12,016,460	6,645,100
1915	240,825	4,978,300	14,423,173	7,195,600
1916	209,386	4,328,400	14,046,054	9,240,100
1917	181,720	3,756,500	13,711,100	9,312,900
1918	153,375	3,170,600[1]	15,341,793	15,341,793[1]

[1] Preliminary figures.

One of the main reasons for this difference was the decreased output from the Conrey dredges, in Alder gulch, Madison County, according to C. W. Gerry. Gold from the properties of the Barnes-King Development Co. was also much less than in 1917, though the company is still one of the chief gold producers in the State. Its dividends in 1918 were $40,000 per quarter. The Boston & Montana continued construction of a railway to its mines at Elkhorn. There is estimated to be up to 800,000 tons of $20 copper-silver-gold-lead ore available for the 500-ton mill to be erected. The Southern Cross mine at Georgetown, from which iron ore is shipped, was the third largest gold producer of Montana. Some rich ore came from the Scratch Gravel mine, in Lewis and Clark County. The Anaconda smelters in 1918 recovered nearly 65,000 oz.

The mine output of silver increased considerably as shown above, making Montana the leading silver producer of the United States. As in past years, most of this silver came from copper ores, but a large part of the increase resulted from zinc ore residues, either those smelted in the East or those treated in the electrolytic plant at Great Falls. The

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Anaconda reduction works recovered nearly 11,000,000 oz. of silver, equal to over 70 per cent. of the State's output. The principal contributors of silver besides the Anaconda properties were Butte & Superior, North Butte, Elm Orlu, Davis-Daly, and the Tuolumne.

Nevada.—This State being one of the largest producers of gold and silver in the Union, its progress is followed closely. The output since 1906 is tabulated below:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1906	506,520	$10,470,704	6,770,611	$4,536,310
1907	585,311	12,099,455	7,083,603	4,675,178
1908	549,682	11,362,941	9,508,464	5,039,486
1909	785,608	16,239,963	10,981,061	5,711,152
1910	913,265	18,878,864	12,479,871	6,739,130
1911	880,106	18,193,397	13,184,601	6,987,839
1912	650,943	13,456,180	14,369,063	8,836,974
1913	570,589	11,795,130	16,090,083	9,718,410
1914	558,064	11,536,200	15,094,432	8,502,662
1915	574,874	11,883,700	14,453,085	7,210,500
1916	438,505	9,064,700	13,682,067	9,000,600
1917	334,894	6,922,900	11,441,000	9,312,900
1918	322,276	6,662,000[1]	10,113,405	10,113,405[1]

[1] Preliminary figures.

The influence of the gold output of Goldfield and the silver output of Tonopah is plainly seen in the table.

Although the Goldfield Consolidated has held the record of being the largest gold producer of Nevada for several years, the gold output declined 40 per cent. last year. Gold from the Tonopah district was also decidedly lower, amounting to $1,200,000. Gold producers having an output of more than $200,000 each were the Nevada Consolidated from copper ore; Aurora Consolidated; White Caps; Elko Prince; Olympic, Union Consolidated; and the Rochester Mines. Other notable gold producers were the Round Mountain property, Nevada Wonder, Dahl Placer, Consolidated Virginia, Comstock Leasing and Consolidated Coppermines. There was a decided decrease in gold from the Seven Troughs district and from Churchill County. As a result of the developments at depth on the Comstock lode, that district produced more than $400,000 in gold, according to V. C. Heikes.

The Goldfield Consolidated Mines Co. suspended work on Feb. 1, 1919, its property being partly sold and partly leased to the Goldfield Development Co., which will lease the mines and operate the mill. A large number of lessees should find remunerative ground in these mines. The new company also proposed to mill a large quantity of $5.60 ore in Combination hill.

After battling against low-grade ore and high costs, the Aurora Con-

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solidated in Mineral County closed its mine and mill late in 1918. The old mines were reopened in 1914. The record is as follows:

Year.	Tons.	Average per Ton.	Yield per Ton.	Cost per Ton.
1918.....	104,086	$3.41	$2.83	$3.48
1917.....	175,447	2.82	2.32	2.42
1916.....	173,270	3.32	2.89	2.46
1915.....	180,529	4.14	3.55	3.56

The cost does not include interest, improvements, etc., but shows what might be done in normal times.

Silver haloid salts in the Nevada Wonder mine were investigated by J. A. Burgess,[1] who said that the chloride, bromo-chloride, and iodide occupy fairly well-marked horizons, their respective positions being downward in the order named. This arrangement is similar to that at Tonopah.

Toward the end of 1918 the Comstock became quiet, and by December, it was decided to allow the water to again fill the workings to the 2600-ft. level. Mining on the lower levels of the Comstock was reviewed by L. H. Eddy.[2] As a result of draining the north-end mines to 2900 ft., filled with water for 33 years, some rich ore was found, especially in the Union, which paid monthly dividends for a while. The electric pumps that lift to the Sutro tunnel were described, while the notes were accompanied by a recent longitudinal section of the line of lode.

The largest output of silver, or about 5,800,000 oz., was produced in the Tonopah district, where the principal contributors were the Jim Butler, Tonopah Extension, Tonopah Mining, Tonopah Belmont, and West End. Large quantities of silver also came from the Nevada Wonder, in Churchill County; and the Rochester Mines and Nevada Packard, in Humboldt County. Smaller outputs came from the Yellow Pine, Prince Consolidated, Elko Prince, and several properties at Virginia City. The Comstock district produced 270,000 oz., and several properties at Rochester produced about 870,000 oz. To avoid considerable litigation at Rochester, a large consolidation was effected early in 1919.

At Tonopah, about 500,000 tons of ore was treated. The output to date is $118,000,000. Dividends last year amounted to $1,371,140. The West End-Jim Butler apex litigation was finally settled, the former winning the suit, and coming into possession of nearly $400,000 held in escrow. This subject was well covered[3] by R. M. Searls. The West End continued development of its Ohio vein. The Tonopah Mining Co. closed its plant at Millers, and sent ore to the Belmont mill. A fair amount of leasing was done, and outside mines reported interesting developments. The "Genesis of the Ores at Tonopah" was the title of

[1] *Min. Sci. Press*, 116, 269 (1918).
[2] *Eng. Min. Jour.*, 105, 1029 (1918).
[3] *Min. Sci. Press*, 117, 43 (1918).

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Professional Paper 104, of the U. S. Geological Survey, by E. S. Bastin and F. B. Laney.

Effect of the war upon Tonopah mining was considered by Jay A. Carpenter,[1] who reached the conclusion that the increased cost of operation was almost wholly counter-balanced by the increased value of the product—silver. An interesting table is given, showing the variation in cost of supplies in the district, reproduced as follows:

	Unit.	Cost.		Increase, Per Cent.
		1913.	1917.	
Drill-steel, ⅞ in. hexagonal	Lb.	$0.1167	$0.2567	120
Blacksmith coal	Ton	19.70	35.00	78
Air-hose	Ft.	0.30	0.45	50
Mine shovels	Doz.	7.50	16.50	120
Powder	Lb.	0.145	0.2325	60
Caps	Case	50.00	150.00	200
Fuse	Case	27.00	40.00	48
Stulls, 6 to 8-in. top	Ft.	0.10	0.10	.....
Timber and plank (native)	M.	19.50	32.00	64
Timber and plank (Oregon)	M.	24.00	38.00	58
Lubricating oil	Gal.	0.25	0.28	12
Mine rail, 8 lb.	Ton	55.00	110.00	100
Iron pipe, 2 in.	Ft.	0.12	0.25	108
Hoisting cable, 1-in. plow	Ft.	0.22	0.35	59
Manganese-steel crusher parts	Lb.	0.145	0.203	40
Battery shoes, chrome	Lb.	0.06	0.085	42
Battery dies, local, cast	Lb.	0.035	0.04	14
Tube-mill liner, local, cast	Lb.	0.053	0.06	13
Danish pebbles	Ton	33.00	55.00	67
Sodium cyanide	Lb.	0.25	0.32	28
Sheet zinc	Lb.	0.10	0.20	100
Lead acetate	Lb.	0.09	0.165	83
Lime	Ton	17.00	19.00	12
Borax glass	Lb.	0.136	0.16	18
Soda ash	Lb.	0.036	0.042	17
Crude oil	Gal.	0.04	0.07	75
Filter canvas	Yd.	0.56	0.70	25

The principal silver event of the year was the development started in the old Gold Mountain district, now called the Divide, 6 miles south of Tonopah. A number of properties (20 in March, 1919) are being exploited, the main one being the Tonopah Divide. This has been opened to a depth of 520 ft., and shows wide veins of rich silver-gold ore. The reserves are estimated as worth at least $5,000,000. Ore was first sent to Goldfield for treatment, but is now sent to Tonopah at the rate of 200 to 300 tons per week. It averages $25 per ton. During 1919 it is expected that several of the many developing companies will find ore.

A geologic description of the Divide district was prepared by A. H. Elftman for the Rosetta company. The rock formations, he considered, are a continuation of some of those found in the Tonopah group, although the character of the veins and the mineralization in the two districts are somewhat different. The Divide breccia, in which the main ore deposits occur, have not been extensively prospected at Tonopah.

[1] *Eng. Min. Jour.*, **106**, 601 (1918).

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New Mexico.—The gold and silver output of this State have been fairly even in value, the past few years showing the following:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1910	23,337	$482,424	843,987	$455,753
1911	36,901	762,808	1,354,540	717,906
1912	37,947	784,446	1,536,701	945,071
1913	42,663	881,926	1,631,273	985,289
1914	58,974	1,219,100	1,777,445	982,927
1915	70,632	1,460,100	2,005,531	1,016,804
1916	65,306	1,350,000	1,729,917	1,138,000
1917	49,590	1,025,100	1,313,700	1,069,350
1918	30,871	638,200 [1]	763,758	763,758 [1]

[1] Preliminary figures.

The decreased output of gold and silver was general throughout the State, according to C. W. Henderson. Mills of the Mogollon district yielded $115,948 in gold and 312,000 oz. of silver, compared with $258,620 and 722,644 oz. in 1917, and $373,068 and 1,008,483 oz. in 1916. In 1918 the mill of the Mogollon Mines Co. was operated steadily, but the new mill of the Socorro Mining & Milling Co., built to replace that destroyed by fire in Oct., 1917, was put in operation in August and ran until Oct. 18, when operations were suspended on account of influenza. Milling was resumed Nov. 18. The output of gold from the Aztec mine at Baldy, Colfax County, was not so large as in 1917. The yield of gold-bearing silicious copper ores of Lordsburg was less than in 1917, as was also the yield of the gold-bearing iron-copper ores of Orogrande. The San Pedro copper-matting plant, in Santa Fe County, was operated for only 3 months in 1918. The product of this plant carries both gold and silver. Gold production from Pinos Altos decreased, and there was only a small yield of gold from Whiteoaks, Lincoln County; but a small addition to the gold output was made by the new amalgamation mills at Parsons and Nogal, also in Lincoln County.

The following table, prepared by S. J. Kidder,[1] manager of the Mogollon Mines Co., shows the relative cost of the ten chief commodities entering into its operations in New Mexico.

Unit, f. o. b.	July 1, 1914.	January 1, 1919.	Increase, Per Cent.
Powder, cwt., Silver City	$12.50	$25.50	104.0
Fuse, case, Silver City	21.00	43.69	108.0
Caps, M., Denver	6.79	18.20	168.0
Drill steel, cwt., Silver City	7.25	14.55	100.1
Battery steel, cwt., El Paso	4.70	10.50	123.4
Cyanide, cwt., New York	20.70	30.00	44.9
Lead acetate, cwt., Mogollon	10.20	19.615	92.3
Sheet zinc, cwt., La Salle, Ill.	6.44	13.00	101.9
Belting, ft., El Paso	0.095	0.194	104.2
Fuel oil, bbl., Silver City	1.55	3.45	122.6

[1] *Min. Sci. Press*, 118, 276 (1919).

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The prices as of Jan. 1, 1919, represent practically the peak of the cost of supplies. There have already been some decreases, notably in the price of powder. Taking the normal prices as given on July 1, 1914, it will be noted that the average advance has been 106.9 per cent. On Jan. 1, 1918, the advance in the cost of the same supplies averaged 96.5 per cent., and on Jan. 1, 1917, 56.74 per cent. It is interesting to observe that the smallest advance was that in the price of cyanide, namely, 44.9 per cent.

Oregon.—Gold and silver mining in this State are practically confined to Baker County in the eastern part, this area yielding 90 per cent. of the total output, and Grant and Josephine counties in the southwest. The dredges are in the Powder River region near Sumpter. The lower gold returns in 1918 were, according to C. G. Yale, due not so much to war conditions as to the decrease in output from the gold dredges, by far the most important single factor in the gold yield of the State. Direct returns received from the dredging companies show a decline of $236,900 in 1918, compared with the total figures from this source in 1917. As the total gold decrease in Oregon for 1918 was $221,500, it is seen that the deep mines of the State more than held their own, notwithstanding the unfavorable conditions due to the war. Moreover, most of this decline was due to the permanent closing down in 1918 of one of the large dredges, its ground having been worked out, and the boat sent to Colorado. There are now three dredges operating in Oregon.

A table of precious-metal production is as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	30,641	$633,407	45,221	$23,967
1912	37,251	770,041	57,081	35,105
1913	78,740	1,627,710	179,036	108,139
1914	76,887	1,589,400	142,552	78,831
1915	90,321	1,867,100	117,947	59,799
1916	91,985	1,901,500	221,887	146,000
1917	81,144	1,677,400	215,700	175,480
1918	60,951	1,260,000 [1]	150,207	150,207 [1]

[1] Preliminary figures.

South Dakota.—The gold output of the Black Hills region, which is the sole producing area of the State, has been remarkably uniform, as the table below shows, this being due to the Homestake mines.

Year.	Ounces.	Value.
1909	318,203	$6,577,836
1910	261,334	5,402,257
1911	359,904	7,439,874
1912	381,745	7,891,370
1913	354,070	7,319,294
1914	354,782	7,334,000
1915	358,145	7,403,500
1916	361,444	7,471,700
1917	357,619	7,392,600
1918	328,305	6,786,700 [1]

[1] Preliminary figures.

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In 1909 and 1910 there were labor troubles at the Homestake, this accounting for the drop. The cyanide plants were also in full operation by 1911. The silver output, a by-product, varied between 164,000 oz. in 1918 and 206,000 oz. in 1912.

Owing to abnormal conditions in 1918, the Homestake stopped 100 of is 1020 stamps, and the company's total fell off $400,000, according to C. W. Henderson. Of the other important properties, the Golden Reward mines and cyanidation mill were closed in the spring of 1918, owing to advances in cost and low-grade ores. The Wasp No. 2 mill was dismantled; the New Reliance was idle; the Bismarck mill was operated for a short period only; the Mogul mine continued operation on custom ore. The Trojan mill and mines were active. Small shipments of lead-silver ore were made from Galena and of copper ore from Roubaix and Hill City.

Early in January, 1919, gold producers met at Deadwood, and asked that Congress remove restrictions on gold, that taxes be remitted, and that every aid be given to increase the yield of new gold. No premium was asked.

Texas.—This is a "silver State," nearly all of this metal coming from the Presidio mine at Shafter. The total for Texas, including that from copper and lead, was 590,000 oz. in 1918. The output during recent years has been as follows:

1910—380,322 oz.	1913—427,553 oz.	1916—664,319 oz.
1911—424,394 oz.	1914—530,817 oz.	1917—583,000 oz.
1912—406,067 oz.	1915—675,473 oz.	1918—590,000 oz.

Utah.—As a silver State, Utah was second in 1918, following Montana. The precious-metal output of these two States is remarkably close, $3,142,000 and $3,170,000 in gold, and 13,400,000 and 15,340,000 oz. of silver, respectively. Practically all these metals in Utah are by-products. The past few years show the following record:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	227,217	$4,696,998	12,473,787	$6,611,107
1912	206,380	4,265,851	13,835,903	8,509,070
1913	172,480	3,565,229	13,084,835	7,903,230
1914	163,362	3,377,000	11,154,916	6,168,669
1915	189,045	3,907,900	13,073,471	6,522,200
1916	186,679	3,859,000	13,545,802	8,911,000
1917	175,133	3,620,300	14,315,300	11,652,650
1918	152,000	3,142,000	13,439,811	13,439,811

The base-metal ores of Utah contain precious metals averaging 12 cts. per ton from the Utah Copper Co. to $37 per ton from the Chief Consolidated lead mine, the largest silver producer in the State. The

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Utah Copper contributes 50,000 oz. of gold and 500,000 oz. of silver to the State's total, while the Chief Consolidated accounts for 4099 oz. of gold and 2,355,000 oz. of silver.

Although the silver increase in 1918 was not large, it is rather surprising that the output was upheld, inasmuch as there were decided decreases in all the other metals, according to V. C. Heikes. The main increase in silver production came from the Tintic Standard mine. Silver from the Park City district was considerably less, though a notable quantity came from the shipments of ore from the Ontario mine. In the Bingham district the Utah-Apex and Utah Copper were the largest silver producers, followed by the Utah Consolidated. Between the Utah-Apex, Utah Consolidated and Utah Metal Companies there was considerable litigation over apex rights last year.

Washington.—Although this State has considerable potential gold-bearing areas, the output at present is not large. According to C. N. Gerry, the decrease in gold output last year was 31 per cent. The greater part of the gold came from the Republic district, but there was a distinct decrease in ores amalgamated throughout the State. Gold from Whatcom County was considerably lower on account of the inactivity of the property of the Boundary Red Mountain Mining Co. From the Republic district approximately 43,000 tons of silicious ore was shipped during the year, against 46,785 tons in 1917. The principal shippers were the Surprise-Lone Pine-Pearl, Last Chance, Knob Hill, Old Republic, San Bil, and Black Tail. The only considerable increase came from the Last Chance mine, which became an important producer during the year. The old Quilp mine was being reopened early in 1919. Operations at Republic are not very profitable. The Consolidated Mining & Smelting Co. of Canada owns a mine here that ensures the Trail smelter a regular supply of silicious ore. The Northport Smelting & Refining Co. now also has a mine here.

The mineral deposits of the Colville Indian Reservation were described by J. T. Pardee in *Bulletin* 677 of the U. S. Geological Survey. Placers are of little importance. Silver is the chief constituent of most of the veins and shear-zones. Gold occurs sparingly in the lodes; though in some it is important.

Gold and Silver in Foreign Countries

Africa

This continent contributes nearly half of the world's gold at present, Rhodesia, Transvaal, and West Africa being the great producers.

Egypt (By R. H. Graves).—The production of gold in Egypt has

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never been large in recent times. It reached 7096 fine oz. in 1915, and fell to 2856 fine oz. in 1918 owing to the increase in working costs and the difficulty of obtaining supplies, which resulted in the closing down of most of the small mines previously producing. At the end of 1918 only one mine, the Barramia, was still operating its cyanide extraction plant, which produces about 150 oz. per month.

The gold of Egypt occurs in quartz veins; it is free-milling and gives good extraction by amalgamation and cyanide. All the occurrences now known were at one time worked by the ancients; they are small and often contain exceptionally rich patches.

The question of transport and water supply for Egyptian gold mines is complicated by their isolated positions in the desert, but the difficulties are not greater than those which have been successfully overcome in other countries.

Rhodesia.—The table below shows the progress of this country:

Year.	Value.	Year.	Value.
1898	£90,000	1909	£2,622,000
1899	230,000	1910	2,568,000
1900	340,000	1911	2,648,000
1901	640,000	1912	2,707,000
1902	744,000	1913	2,903,000
1903	870,000	1914	3,530,000
1904	1,000,000	1915	3,823,000
1905	1,500,000	1916	3,889,000
1906	2,060,000	1917	3,495,000
1907	2,170,000	1918	2,652,000
1908	2,525,000		

The mineral industry of Rhodesia was not only hampered during 1918 by the difficulties arising out of the war, but also suffered from the floods which occurred on the railway system in February, and from the influenza epidemic which severely restricted the output for the last three months of the year. The silver output was 175,722 oz.

At the annual meeting of the Rhodesia Exploration company in London, early in January, 1919, the chairman, H. G. Latilla, made some interesting remarks on certain developments. This company's mining department has been in litigation with the Globe & Phoenix company over extra-lateral rights, losing in two courts, but it has appealed. Mining laws of southern Rhodesia were based largely on United States laws, hence the apex dispute. The case was recently submitted to Curtis H. Lindley of San Francisco, who considered that the facts were in favor of Rhodesia Exploration, but this company finally lost, and now has a big bill of damages to pay. The Globe & Phoenix treated 4733 tons of $18 ore in December.

Some of the monthly outputs (December) were Cam & Motor, 11,266

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tons for £13,931; Eldorado, 4954 tons for £11,516; Lonely Reef, 4240 tons for £17,701; Shamva, 27,899 tons for £19,717; and Wanderer, 9120 tons for £3879.

About the middle of 1918, the Rhodesia Munitions and Resources Committee issued a report on the mineral possibilities of the country; while earlier in the year the Umtali gold belt was reported on by G. E. V. Zealley for the Geological Survey of Southern Rhodesia. The region is on the border of Portuguese East Africa, with the railroad from Salisbury passing through. The Rezende (5000 tons of 35s. ore monthly) and Penhalonga mines are in the belt. A number of claims were taken up in 1918. Granite occupies the country north and south of the schist. The gold deposits are mainly in the schist. Many lodes carry much silver and little gold. Sulphides are common, including arseno-pyrite and galena. The amount of precious metals in the sulphide zone is too low for individual operation, so generally only the oxide ore is extracted. So far, the field is worked by small syndicates, which have a number of difficulties to face.

Transvaal.—A study of the monthly returns of the Rand and outside fields shows that after August, 1918, when the yield was 740,210 oz., there was a drop each month, that for December being 100,000 oz. less than for August. The cause of this decrease was the epidemic, which resulted in high mortality among the Kaffir laborers. The year started

TRANSVAAL GOLD PRODUCTION
Witwatersrand District

Year.	Tons Milled.	Value.	Value per Ton Milled, Shillings.	Outsides Mines, Value.	Total Value for Transvaal.	Dividends.
1884–89	1,000,000	£2,440,000	48.8	£238,231	£2,678,231	.....
1890	730,000	1,735,491	47.4	134,154	1,869,645	.....
1891	1,154,144	2,556,328	44.2	367,977	2,924,305	.....
1892	1,979,354	4,297,610	43.3	243,461	4,541,071	.....
1893	2,203,704	5,187,206	47.0	293,292	5,480,498	.....
1894	2,830,885	6,963,100	49.2	704,052	7,667,152	.....
1895	3,456,575	7,840,770	45.2	728,776	8,569,555	.....
1896	4,011,697	7,864,341	39.2	739,480	8,603,821	....
1897	5,325,355	10,583,616	39.7	1,070,109	11,653,725	.....
1898	7,331,446	15,141,376	41.3	1,099,254	16,240,630	.....
1899	6,872,750	15,067,473	48.8	661,220	15,728,693	.....
1900	459,018	1,510,131	65.8	.....	1,510,131	.....
1901	412,006	1,014,687	49.2	81,364	1,096,151	.....
1902	3,416,813	7,179,074	42.0	74,591	7,253,665	.....
1903	6,105,016	12,146,307	39.8	442,941	12,589,248	.....
1904	8,058,295	15,539,219	38.5	515,590	16,054,809	.....
1905	11,160,422	19,991,658	35.8	810,416	20,802,074	.....
1906	13,571,554	23,615,400	34.8	964,587	24,579,987	.....
1907	15,523,229	26,421,837	34.0	981,901	27,403,738	.....
1908	18,196,589	28,810,393	31.6	1,147,217	29,957,610	.....
1909	20,543,759	29,900,359	29.1	1,025,429	30,925,788	.....
1910	21,432,541	30,703,912	28.5	1,297,823	32,001,735	.....
1911	23,888,258	33,543,479	28.1	1,498,006	35,041,485	.....
1912	25,486,361	37,182,796	29.2	1,574,765	38,757,560	.....
1913	25,628,432	35,812,605	27.8	1,545,435	37,358,040	.....
1914	25,701,954	34,124,434	26.5	1,463,641	35,588,075	£8,073,436
1915	28,314,579	37,264,992	26.3	1,362,469	38,627,461	7,619,416
1916	28,525,252	38,107,909	26.7	1,377,025	39,484,934	7,095,066
1917	27,251,960	37,017,633	27.1	1,306,288	38,323,921	6,556,188
1918	24,922,763	34,823,017	27.9	945,671	35,768,688	5,330,966

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with 176,424 natives at all gold mines, increasing to 183,055 in March; by September, normal movements lowered the total to 179,399, but at the end of the year there were only 152,606 boys available, a serious deficiency. Early in 1918 there were abnormal rains in the region, flooding many mines, so this also resulted in lower yields. As shown below, the past year finally showed a decrease of £2,555,233, equal to 541,551 oz. of gold.

Dividends are declining each year, due to fewer companies making disbursements (33 in 1918 against 38 in 1917), lower-grade ore, and increased costs. The total paid by Transvaal mines to the end of 1918 is £135,655,857. The gold yield since 1884 is £588,988,075, so dividends equal 23 per cent. of the gross production.

There were 50 mines on the producing list in 1918. An average of 8930 stamps were dropping, and 337 tube-mills were grinding. These totals may be compared with 9500 stamps and 332 tubes in 1917.

Abnormal conditions last year were the cause of much discussion among low-grade companies, and at the beginning of the year a select committee was appointed by the Union Government to report on this question. After hearing evidence given by representatives of the Transvaal Chamber of Mines and the chief gold producers of the country, they published their report in April. They did not recommend that help should be given by the Government. They suggested that the Bank of England should reduce the insurance and freight on raw gold from 25s. per £100 to 17s. 6d, and that the Government should remit its share of claim licenses. It was also proposed that, in the event of the low-grade mines being compelled to close, a fund should be established to continue pumping, and otherwise keep the mines in position to reopen after the war.[1]

The seriousness of the situation in those countries is reflected in a statement by A. E. Waller, chairman of the Transvaal Chamber of Mines, to the effect that out of 46 companies operating in the Transvaal, 6 were running at a loss and 15 were barely paying expenses.

The opinion of the Committee appeared to be that, if the low-grade mines closed, the other mines would benefit by the use of their labor, and thus keep up production. The native labor thus freed could, no doubt, be utilized, but it is questionable whether all of the white employees of the low-grade mines could be taken over by the higher-grade producers. The question remained in abeyance until July, when a representative gathering of the gold producers of the Empire was held in London, and the attention of the Government was called to the urgency of the position. This report is discussed in the introduction to this chapter.

[1] H. F. Marriott, *Eng. Min. Jour.*, **107**, 118 (1919).

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Developments in the Far East Rand were generally satisfactory. The New Modderfontein, the greatest gold mine on the Rand, increased its dividends from 28s. in 1917 to 41s. 6d. in 1918. The Government Gold Mining Areas, Geduld, and Modder Deep paid a little more than formerly; but the Brakpan and Modder B. paid a little less. The Springs Mines paid an initial dividend. In 1917 the Government decided against mining operations being conducted directly by the State, and therefore a Mining Leases Bill to deal with the areas still under State control was passed early in 1918. The law established a Mining Leases Board, the members of which are Sir Robert Kotze, government mining engineer; H. E. Farrer, Secretary of Finance; F. E. Kantback, Director of Irrigation, and Sir William Hoy, general manager of the South African Railways. It also fixes the maximum and minimum scales for the Government's share in profits, and makes provision for larger mynpachts (mine leases).

The 2235 claims on the west section of the Farm de Rietfontein, No. 14, which were put up for tender in June, 1917, but were unallotted, were offered again for tender early in 1918. The tenders received by the Government were from the Anglo-American Corporation, the Central Mining & Investment Corporation, and the General Mining & Finance Corporation. The result was announced on Mar. 21, and that of the Anglo-American was accepted. A new company has been formed to deal with the ground under a title of West Springs, Ltd., with a capital of £1,400,000 in £1 shares, to be issued at par. The Springs Mines, Ltd., will grant facilities for beginning development from its property, pending the sinking of the two shafts arranged for. In return for this accommodation it has been given an option over a block of reserve shares. The technical management is in the hands of the Consolidated Mines Selection.

The lease of the 2050 claims on Farm de Springs acquired last year by the Johannesburg Consolidated Investment Corporation was transferred at the end of February, 1918, to a new company registered as New State Areas, Ltd. Two vertical shafts are to be sunk forthwith, and it is estimated that the reef will be cut at about 3600 feet.

In 1917 Springs Mines obtained an extension to its property of 2235 claims on the eastern section of the Farm de Rietfontein, No. 14. A new shaft has been started, which, it is estimated, will be sunk to a depth of about 4000 ft., and should be completed in about 4 years. In the meantime, development is being pushed from the present mine into the new area, with a view to obtaining an early production of ore therefrom. The capacity of the reduction plant is to be immediately increased from 30,000 to 40,000 tons per month. Its eventual capacity is placed at

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1,400,000 tons per annum. This, however, cannot come into operation for several years.

At Modderfontein East, Ltd., which is still in the development stage, the comprehensive program for opening the reef throughout the property is proceeding. At the end of September the two new shafts, Nos. 2 and 3, were, respectively, 898 ft. and 818 ft. in depth. The deep-level area is being rapidly developed from the Cloverfield shaft, and an exploratory drive has entered the outcrop section from Modderfontein B mine.

The footwall beds of the Far East Rand reef were briefly discussed by L. W. Macer.[1] It has been generally assumed that the stratigraphy is simplified by existence of the slate footwall, correlatable with the black bar of the Central Rand, so easily recognized that it constitutes a reliable indicator for the payable reef of this area. Mr. Macer pointed out that this deposit is of a variable nature, both petrologically and in its mode of occurrence, and is not so readily distinguished as is generally supposed.

In discussing the new mines of the Far East Rand, A. C. Key[2] gave details of the Union Government's new leasing system and method of calculating profit percentage. Up to November, 1918, over 6500 claims (1½ acres each) had been leased. The calculations appear to be simple. The royalty exacted varies from 2.6 per cent. of the profit when this is 12 per cent. of the revenue to 50 per cent. when the profit is 60 per cent. or over.

The same writer[3] also compared wages, working costs, and ore-reserves of the Rand. In October last, mechanics at the mines asked for a raise, making their wage £8.20 per week, equal to 42 per cent. above pre-war rates, and 23 per cent. above present rates. A similar increase to all employees would involve £1,840,000, equal to 1s. 4d. (32 cts.) per ton. Of the 96,000,000 tons of ore in 50 mines, half carries 6½ dwt. or less. This is worth 27s. 6d. per ton, allowing little margin from the cost of 20s. 6d., plus metallurgical losses. So, with the fixed price for gold, high costs, and low grade of ore, any increase in wages is dangerous to the industry.

The most important paper dealing with the Rand during 1918 was the presidential address of H. F. Marriott before the Institution of Mining and Metallurgy in London on Apr. 11, 1918. Mr. Marriott is consulting engineer to Wernher, Beit & Co. and corporations controlled by that firm, whose annual gold output is 49 per cent. of the total of the Rand. The points discussed were early exploration, boreholes, shaft-sinking, general lay-out of shafts, pumping, underground haulage, sampling, mining methods, and filling empty workings. The principal point in

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **19**, 70 (1918).
[2] *Eng. Min. Jour.*, **106**, 821 (1918).
[3] *Eng. Min. Jour.*, **106**, 954 (1918).

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Mr. Marriott's paper was production and profit, and the value of the ore at depth, especially along the Central Rand. From a close study he had never been able to ascertain any general indication of depreciation of gold-value at depth. Summarizing, he said that the average of the Main Reef Leader of the Central Rand, as disclosed by the original valuation, was 32.22 shillings ($7.73) per mine-ton. Mining here is conducted to a vertical depth of 5350 ft., and 9800 ft. from the outcrop, measured on the dip of the reef. To the end of 1916, this area had yielded £170,463,923 from 93,468,055 tons of ore, an average of 36s. 6d. ($8.76) per ton, a close confirmation of the original sampling. To that date the whole Witwatersrand had yielded £492,364,791 from 311,755,786 tons, an average of 31s. 7d. ($7.58) per ton. These conclusions were disputed by T. A. Rickard,[1] who showed that the neighboring deep shafts of the Village Deep mine, which is at the center of the Central Rand, exposed such poor ore that they were abandoned. The edges of the Central Rand show from 24 to 19.3s. ore at one end, and from 31.1 to 27s. at the other. The table prepared by Mr. Marriott was, in effect, the graph of an ore shoot, in the center of which was the Village Deep, with rich ore. In short, Mr. Marriott cited an exception to prove a rule.

West Africa.—The remarks of the chairman of the Abosso Gold Mining Co., T. F. Dalglish, at the meeting held in London in December, 1918, fairly well cover general conditions in this region. He said, in part:

> We have again to record an insufficiency of labor during the year. The attraction of other industries, particularly that of cocoa, has withdrawn much labor which would have been available for the mines. The extension of road-making by the Government to facilitate the transport of cocoa and other work started by it are serious facts which we have to face. There is no question that the native, all things being equal, prefers field work to mining, and it is only by endeavoring to make the work on our property attractive that we are able to maintain the present number of natives we employ. We have made many representations to the authorities on the subject, and continue to do so in the hope that some arrangements may be made to obtain boys from neighboring countries, as the resources of the colony in this respect appear to be fully occupied in the industries now in operation. I referred in my speech last year to the anomalous position in which the gold-mining industries had been placed by the Government. Despite the fact that costs have steadily increased, the Government continues to commandeer all gold at the pre-war price although it commands a much higher figure in the open market. Having regard to the conditions obtaining in the Gold Coast Colony, our mine must be classed as low grade ($7.80 per ton). Unless something is done by the Government to ameliorate the conditions, it is difficult to see how we and other mines of the same class are to pay reasonable dividends.

The gold output of the colony in 1918 totaled about £1,300,000, against £1,530,000 in 1917. The labor shortage and influenza were the chief factors in the lower result. The Abosso treated 102,256 tons of

[1] *Min. Sci. Press*, 117, 72 (1918).

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29s. 9d. ($7.10) ore, giving a loss of £1795. Others in the list are the Abontiakoon, Ashanti Goldfields (105,452 tons of 20.56-dwt. ore and profit of £159,621), Prestea Block A, and Tarquah.

ASIA

China.—It is almost impossible to learn of anything new regarding precious metals in this great country, but the following excerpt from an editorial in the January, 1919, issue of the well-informed *Far Eastern Review*, published at Shanghai, points to developments in the right direction.

"The increasing activity in mining that is being displayed throughout the country should compel the Government to give immediate attention to the necessity of re-modeling the mining laws so that work may be carried on with security, with borrowed foreign money if necessary, and with proper safeguards to investors. Above all provision is necessary for the unobstructed operation of mining areas with foreign capital under foreign control and management. No proper development of the mineral resources of this country is possible until foreign experience and financial help are obtained, and they cannot be obtained without proper inducements and laws which will afford adequate protection and permit the investor to determine how his money shall be spent. China's future depends upon sensible legislation with regard to mining as well as every other avenue for the employment of capital in economic development. The wealth of every great nation comes primarily from the earth, and other Governments have provided the inducements for its extraction, but unhappily the Chinese have not yet awakened to that fact, and that is what they have to be taught."

"Mineral Enterprise in China" is the title of a valuable book[1] by W. F. Collins. It is doubtful whether any similar work exists, covering every phase of mining in China. The resources, apart from coal, are not unknown or vast, as generally assumed, and the mineral deposits are more disappointing than otherwise.

India.—The table following shows how remarkably even has been the output of this country. The Kolar goldfield in Mysore accounts for over 90 per cent., and the mines are all under one control.

Year.	Value.	Year.	Value.
1890	£397,000	1905	£2,490,000
1891	516,000	1906	2,500,000
1892	620,000	1907	2,160,000
1893	870,000	1908	2,158,000
1894	600,000	1909	2,167,000
1895	730,000	1910	2,105,000
1896	1,200,000	1911	2,150,000
1897	1,500,000	1912	2,265,000
1898	1,620,000	1913	2,300,000
1899	1,740,000	1914	2,340,000
1900	1,930,000	1915	2,370,000
1901	1,960,000	1916	2,300,000
1902	2,100,000	1917	2,214,000
1903	2,380,000	1918	2,080,000
1904	2,440,000		

[1] The Macmillan Co., New York, 1918.

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The December yields of the group were:

Mine.	Tons.	Fine Ounces.
Balaghat	2,375	2,313
Champion Reef	11,782	6,805
Mysore	25,751	14,470
Nundydroog	8,828	6,730
Ooregum	12,200	7,913

The totals from this group are surprisingly large.

The two Indian Mints coined an enormous quantity of silver during 1918, the output in August, for instance, being 55,289,290 rupees ($17,689,373). Early in 1918 it was announced that a gold refinery was to be erected in India, to refine the output of the country's mines.

Air-blasts or rock-bursts have been a continual source of trouble in the Kolar mines, a serious one happening in September, 1918. A good deal has been written on the subject, the latest report being by W. F. Smeeth, chief inspector of mines for the State of Mysore. He started these investigations about 17 years ago. In his report Mr. Smeeth dealt with timbering in the early days and now, sinking shafts in ore and in country rock, pillars, stoping, filling empty workings, and support of the hanging wall as soon as possible. The bursts are sporadic. A working may be driven for many feet, and even for thousands of feet, with no sign of trouble, when, without warning, a burst or a series of bursts may occur, or a zone or patch of rock may start firing itself off for some considerable time, and the working may have to be suspended until the display is finished. It does not seem possible to suggest any means of preventing the occurrence of rock-bursts, but a great deal has been done to protect workmen against the more numerous bursts which are not of exceptional violence. In vertical shafts a movable protective shield is provided below the point to which the brick lining has been put in. In underlie shafts and in many winzes, drives and cross-cuts, either permanent or temporary timbering is carried as close to the working faces as possible. When a patch of ground which shows a tendency to burst is being driven through, work is frequently suspended to give the strains a chance to relieve themselves. Some bursts are so unexpected or so violent that no amount of care or protection is of any use, and regrettably large loss of life, or injury, occasionally occurs. For some years past a well-equipped seismological observatory has been maintained on this field.

Japan.—Mining news from this empire is generally scarce, although companies operating in Korea publish a good deal on current progress. Really the latest authentic data from companies in Japan proper are contained in "The Mines Handbook" (Weed), issued in 1918. The following are the principal producers:

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Company.	Mine.	Gold, Ounces per Annum.	Silver, Ounces per Annum.
Fujita	Zuiho; and by-products of copper and lead ores	27,000	1,169,000
Furukawa	Kijo (gold), Innai (silver); and by-products	.....	1,500,000
Kuhara	Kapson; and by-products	9,000	120,000
Mitsubishi	By-products	45,700	883,000
Mitsui	By-products	1,500	296,000

The Zuiho mine is on the island of Formosa. The ore is silicious, carrying pyrite and other sulphides. Some of the ore is clayey. The annual output is around 5000 oz. of gold. The Kijo property yields lead-gold ore, but gold lodes are being developed. The Innai produces 400,000 oz. of silver yearly. A cyanide plant is in operation.

A reduction in the size of 50-sen, 20-sen, and 10-sen silver coins was announced late in 1918 by a Japanese ordinance, the reason being not only that the silver coins in use at present are rather inconvenient to carry, but because of the practice of melting them into bullion on account of the appreciation in the market price of silver. The new silver coins will be smaller in size by about $\frac{1}{100}$ of an inch than the preceding coins, and will contain a smaller quantity of silver. The Government intends to mint Y20,000,000 ($10,000,000) in the three denominations during the current fiscal year, and gradually to withdraw the old coins from circulation. A United States Consular Report early in 1919 contained some figures relating to Japanese metals: In 1917, there was 226,122 oz. of gold extracted from ores and 1402 oz. from placer workings; also 7,111,720 oz. of silver. In the first half of 1918 the gold yield was 122,632 oz. and silver 3,166,344 oz. The silver output of 1917 was an increase on previous years.

Korea.—The important gold producers on this peninsula are the Chicksan, Oriental Consolidated, and Seoul mining companies. The first is operating a dredge, while the other two contiune their extensive mining operations.

The financial statement of the Oriental Consolidated during the year ended June 30, 1918, shows a revenue of $1,528,525. Of this, $393,464 was profit. The surplus on June 30, 1917, was $230,684, and a year later $409,453, after paying dividend. Assets include cash in banks $531,114; supplies, $453,514. Sundry debtors total $222,799. Dividends amounting to $214,695 were paid in September, 1917. This made $7,938,645 to that date, since when another distribution has been made. Development in the five main mines totaled 34,697 ft., 3000 ft. short of the previous year. On prospects, 1226 ft. was accomplished. Results at the Tabowie were unsatisfactory and discouraging; at the Taracol and

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Chintui, satisfactory and encouraging; the Charabowie was worked out, while the Tongkol was not as good as expected. Work on outside areas was generally unsuccessful. Ore-reserves total 775,000 tons, valued at $5.27 per ton. The Tabowie contains 485,000 and the Taracol 238,000 tons. Three mills—the Tabowie, Taracol, and Maibong—with 200 stamps, crushed 303,672 tons of $5.90 ore. The Maibong was shut down permanently in July, 1918. By amalgamation there was $845,142 saved. Concentrate treated at the Tabowie and Taracol plants amounted to 27,462 tons, yielding $600,729, or 83.2 per cent. The Maibong tube-mill plant treated 2060 tons for $45,933, the recovery being 91 per cent. The total extraction of gold was $1,493,318, equal to 90.3 per cent. of the gross value of the ore. Since work first started the yield has been $29,423,235 from 4,766,270 tons of ore. Total receipts were $5.03 per ton, operating costs $3.06, and construction 10 cts., leaving a profit of $1.87 per ton. Reports of this company are always given in great detail. The comparison of cost of supplies shows an enormous difference between 1914 and 1918, between 1917 and 1918 the rise being from 10 to 130 per cent. The Unsan Mines, as the concession is named, was fully described by H. J. Evans and K. F. Hoefle.[1]

The Seoul Mining Co. continues annual dividends amounting to $250,000. Bullion extracted in 1918 totaled $1,446,000. The average value extracted per ton, on 201,151 tons, was about $7. Costs in 1917 were $4.02 per ton.

Ore-reserves in the various mines totaled 816,957 tons, averaging $8.57 per ton. The Suan mine was expected to be exhausted by the end of 1918. Tul Mi Chung contains 484,670 tons of $10.30 ore (gold-copper-silver) and Soctarie, 267,717 of $4.93 ore (tungsten-gold-copper). Tailing at Tul Mi Chung amounts to 180,000 tons, worth $2.78 per ton. The total amount of work done during 1917 was 31,312 ft., the greatest in any year. Improvements to mills included at the Tul Mi Chung mine a ball granulator and a Dorr classifier of the bowl type. While the recovery of copper is high, that of the gold is low. An immense amount of experimenting has been done to improve this condition, at the mine, in America, and in England. Tests completed indicate an extraction of 70 per cent. of the gold left in the tailing, with a cyanide consumption of 2.3 lb. per ton of tailing. For the present, this work will proceed, as the proposed 600-ton plant cannot be erected as long as existing conditions prevail. Cyanidation will supplement flotation. The total recovery of gold from the ore will be 85 per cent., against 60 per cent. at present. Another problem is the tungsten-gold-copper ore of the Soctarie mine. The valuable mineral is the 0.3 per cent. scheelite content. Separation

[1] *Min. Sci. Press*, 118, 419 (1919).

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of the concentrate into marketable products is the desired end, and this was fairly well solved. Twenty stamps of the Suan mill will be used for this ore, after certain alterations are made.

The geology and ore deposits of the "Collbran contact," that is, the contact between the intruding granite "boss" and the sedimentary beds, along the line of which ores is found, was described by D. F. Higgins.[1] The Suan and Tul Mi Chung mines are in limestone, the only limestone surficially in contact with the granite.

Some interesting sidelights on life in Korea may be obtained by reading M. Eissler's "My Voyage in Korea."[2] Mining is given brief mention.

Philippine Islands.—Preliminary estimates of the U. S. Geological Survey place the 1918 gold output at 44,200 oz. worth $913,700, and 12,600 oz. of silver. This is a decrease of 60 per cent. when compared with the 1917 yield of gold. Considering that this is an American possession, very little mining news is available. The Bureau of Science is doing good work, but its reports are always very much behind.

According to E. H. Clausen,[3] in describing the mines and mills of the Aroroy district of Masbate island, mining in the Philippines is still in its infancy. Much of the country is mountainous and unexplored; capital has not been made acquainted with possibilities; efficient labor is a serious problem. In the Aroroy district are the Colorado, Keystone, and Syndicate lode mines. The first has a 175-ton mill and cyanide plant, the third has a 140-ton cyanide mill, treating $8 and $11 ore, respectively. In the Baguio district of the main island—Luzon—the Benguet Consolidated in 1918 treated 23,539 tons of $21.35 ore, extracting 89 per cent. at a cost of about $6 per ton. In the Paracale district of Luzon are most of the dredges. These and that at Mambulao were described briefly by Charles Janin.[4] He says that Philippine placer ground, so far as shown by dredging, differs from other countries in the extremely large proportion of fine material and clay, due to the tropical climate. In the last report of the Philippine Dredging Co. it was stated that four boats dug a total of 2,198,253 cubic yards, yielding 17,825 oz. of gold. This is an Australian company and is on a dividend-paying basis.

AUSTRALASIA

The above designation includes the Commonwealth of Australia and Dominion of New Zealand. The combined gold production is as follows:

[1] *Econ. Geol.*, Jan., 1918.
[2] *Oriental Press*, Shanghai, China, 1918.
[3] *Min. Sci. Press*, 116, 615 (1918).
[4] *Bull.* 127, U. S. Bureau of Mines, 1918.

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Year.	Value.	Year.	Value.
1890	£6,004,904	1905	£17,644,846
1891	6,280,382	1906	16,901,649
1892	6,842,044	1907	15,542,599
1893	7,128,610	1908	15,063,778
1894	8,282,241	1909	14,711,409
1895	8,870,193	1910	13,450,168
1896	8,995,624	1911	12,368,406
1897	10,886,835	1912	11,225,059
1898	11,791,724	1913	10,836,072
1899	16,174,426	1914	9,625,316
1900	15,141,478	1915	10,090,339 [1]
1901	15,943,761	1916	8,432,000
1902	17,032,402	1917	7,490,000
1903	18,332,515	1918	6,320,000
1904	17,984,838	.....	.....

[1] Gain due to New Zealand exporting gold held on account of war.

PRODUCTION OF GOLD IN AUSTRALASIA BY STATES (*a*)
(In fine ounces)

State.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
New South Wales	181,121	165,295	149,657	124,507	132,498	108,144	85,092	87,045
Northern Territory	(*e*) 5,000	(*e*) 5,000	(*e*) 4,600	(*e*) 4,500	2,532	(*e*) 1,540	(*e*) 1,500	
Queensland	386,164	347,946	265,735	248,395	249,360	215,162	179,305	130,123
South Australia	3,537	6,592	6,556	6,258	6,081	7,769	7,145	7,160
Tasmania	31,101	37,973	33,440	26,243	18,547	15,790	14,496	11,286
Victoria	504,000	480,131	434,932	409,706	329,068	256,643	204,708	158,827
West Australia (*b*)	1,338,987	1,282,658	1,314,044	1,232,974	1,210,109	1,061,398	970,317	876,510
Commonwealth	2,449,910	2,325,595	2,209,700	2,053,402	1,948,372	1,666,446	1,462,563	1,276,951
New Zealand (*c*)	427,385	310,796	343,627	361,272	422,825	292,620	(*e*)280,000	(*e*)210,000
Total Australasia	2,877,295	2,636,391	2,553,327	2,414,674	2,371,347	1,959,066	1,742,563	1,486,951

(*a*) From official publications. (*b*) Production reported by the Mines Department; in previous volumes the statistics have represented exports. (*c*) Exports. (*e*) Estimated, real figures withheld on account of war.

The past year was very unfavorable for gold mining throughout these regions, the main causes being lower-grade ores, shortage of labor and supplies, high prices for supplies, and the lower purchasing power of the metal extracted. Representations were made to the British Government asking for a bonus on gold, a meeting of producers being held in Melbourne as late as Janauary, 1919, the result of which will be found in the introduction of this chapter. No new districts or mines were developed in 1918, so there was nothing to back up the decreases in all of the older centers.

New South Wales about held its own in gold, and as usual contributed most of the silver, a by-product from the Broken Hill lead-zinc mines. Queensland dropped off about 30 per cent. when compared with 1917. The Mt. Morgan copper mine accounts for fully 60 per cent. of the State's gold yield. Tasmania probably held up its output, which is mostly

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from the Mt. Lyell copper mine. Victoria fell away badly, about 30 per cent. The only bright spot in that State was at Bendigo, where the Bendigo Amalgamated Goldfields, a consolidation of about 40 companies, is exploiting eight lines of "reef." Most of the shafts are down 2000 ft., some over 3000 feet. Four miles of new work and much diamond-drilling was done last year. The mills treated 146,769 tons of ore averaging £1 3s. ($5.30) per ton. This company formed a mutual association so that employees could participate in profits and benefits. Replacement in the Bendigo quartz veins, and its relation to gold deposition, was the subject of an investigation by F. L. Stillwell.[1] The geology, reefs, faulting, occurrence of gold, factors influencing deposition, etc., were all discussed. Western Australia declined about 10 per cent. from 1917. This was general. At Kalgoorlie, the great center, profits are shrinking fast, even the Great Boulder, which has paid dividends for many years without a break, passed its distribution in September. The Ivanhoe now makes a monthly profit only 25 per cent. of what it was in 1914. As the big companies curtail operations, tributers lease certain blocks, and now there are hundreds of lessees at work on the "Golden Mile," some of whom are doing very well. In the Westonia district it was proposed to amalgamate the four principal properties for better results. An important series of articles on gold mining in this State, by Thomas Butement, of the Kalgoorlie School of Mines, appeared in *Chemical Engineering and Mining Review*[2] of Melbourne, Victoria.

New Zealand reported another reduction in output. The Ohinemuri field in the North Island, which yields half of the whole Dominion, dropped off nearly 20 per cent., and is now only 55 per cent. of the £1,296,000 in 1910. This region has produced £17,000,000 in 19 years. In it are the famous Waihi mine, Waihi Grand Junction, and Talisman. In the South Island, the Blackwater and Progress mines continued normal operations, but dredging declined considerably.

CANADA

In spite of a good increase in the gold output of British Columbia in 1918, the suspension of operations at several mines in the Porcupine district of Ontario resulted in a decrease of $580,000 from the whole Dominion. Silver dropped slightly in the western Province, and considerably at Cobalt, Ontario, leaving a general deficit of 1,000,000 oz. for the year. The following tables give the precious-metal output over a series of years:

[1] *Econ. Geol.*, 13, 100 (1918).
[2] June, July, Aug., Sept., Oct., Nov., Dec., 1918.

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GOLD

1890	$1,149,776	1905	$14,159,195
1891	930,614	1906	11,502,120
1892	907,601	1907	8,382,780
1893	976,603	1908	9,842,105
1894	1,128,688	1909	9,382,230
1895	2,083,674	1910	10,205,835
1896	2,754,774	1911	9,781,077
1897	6,027,016	1912	12,648,794
1898	13,775,420	1913	16,598,923
1899	21,261,584	1914	15,983,007
1900	27,908,153	1915	18,977,901
1901	24,128,503	1916	19,234,976
1902	21,336,667	1917	15,272,992
1903	18,843,590	1918	14,687,000
1904	16,462,517		

SILVER

Year.	Ounces.	Cents per Ounce.
1904	3,577,526	57.22
1905	6,000,023	60.35
1906	8,473,379	66.79
1907	12,779,799	65.33
1908	22,106,233	52.86
1909	27,529,473	51.50
1910	32,869,264	53.49
1911	32,559,044	53.30
1912	31,955,560	60.83
1913	31,845,803	59.79
1914	28,449,821	54.81
1915	26,625,960	49.68
1916	25,459,741	65.66
1917	22,221,274	81.42
1918	21,284,600	96.84

The preliminary report of John McLeish, chief of the Division of Mineral Resources and Statistics of the Department of Mines at Ottawa, contained the following remarks:

Gold.—The total production of gold in 1918 amounted to 710,526 fine oz., valued at $14,687,875, compared with 738,831 oz., valued at $15,272,992, in 1917. Of the total production in 1918, $2,411,245 or 16.4 per cent. was derived from placer or alluvial mining; $9,080,826 or 62 per cent. was in the form of bullion and refined gold; and $3,195,804 or 22 per cent. contained in matte, blister copper, residues and ores exported.

The production in Nova Scotia was only 1195 oz., valued at $24,700, the smallest ever recorded. The decrease is mostly attributed to the great increase in cost of labor and material.

The production in Quebec is derived partly from the pyritic ore of the Eastern Townships and partly from the zinc-lead ores of Notre Dame des Anges, Portneuf County, and amounted to 1855 oz., valued at $38,346. Much of this gold is not paid for by the smelters.

The Ontario production was 411,270 oz., valued at $8,501,705, being about 58 per cent. of the total production of Canada. The production in 1917 was reported as $8,749,581, and in 1916, the highest recorded, it was $10,180,485. The decrease of the last 2 years is attributed to the high cost of labor and supplies, but an increased production in 1919 may be anticipated with more labor available and lower costs of materials.

The production from Manitoba was 6755 oz., valued at $139,638, against 440 oz., valued at $9095, in 1917. This was derived from the gold

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and copper ores of Herb and Schist lakes in the new Pas mining division in northern Manitoba.

The production in British Columbia in 1918 was 187,069 oz., valued at $3,867,059, against 133,742 oz., valued at $2,764,693, in 1917, an increase of about 40 per cent., due to increased activity at the Rossland mines and to the entry of the Belmont Surf Inlet Mines at Surf Inlet on the list of important producers. Nevertheless it is much below the usual production of five to six million dollars a year.

The production from the Yukon Territory amounted to 102,382 oz., valued at $2,116,424, a decrease of 42 per cent. from that of 1917, and is much below the average output of this district during the last 10 years. In addition to the alluvial gold there is included a small recovery from the gold and copper-gold ores of the Conrad and Whitehorse districts.

Exports of gold bullion, gold-bearing dust, nuggets, gold in ore, etc., in 1918 are recorded by the Customs Department as $10,040,813, against $15,929,051 in 1917.

Silver.—Production of silver in 1918 is estimated at 21,284,706 fine oz., valued at $20,597,540, against 22,221,274 oz., valued at $18,091,895, in 1917, a decrease of 4 per cent. in quantity, but an increase of 14 per cent. in value, and exceeded in value the previous maximum reached in 1912.

The production in Ontario amounted to 17,109,389 oz., valued at $16,557,098, or 80 per cent. of the total silver production for Canada. In 1911, when the Cobalt district production was at its maximum, the percentage was 94. The production was derived from the ores of Cobalt and adjoining silver districts, with the exception of 68,677 oz. credited to the gold mines. Of the total Ontario production, 9,410,435 oz., or 55 per cent., was recovered in the mills of Cobalt; 4,992,469 oz., or 29 per cent., from southern Ontario smelters; and 2,706,485 oz., or 16 per cent., from ores treated in the United States. The production for Ontario in 1917 was 19,301,835 oz., valued at $15,714,975. Of this production, 51 per cent. was recovered in the district and 34 per cent. in the smelters of southern Ontario, leaving a balance of 15 per cent. as recovered from ores treated in the United States.

The production in Quebec was 147,316 oz., valued at $142,561, against 136,194 oz., valued at $110,885, in 1917, and is derived from the pyritic ores of the Eastern Townships and the zinc-lead ores of Notre Dame des Anges, Portneuf County.

The Manitoba production amounted to 14,033 oz., valued at $13,580, against 7201 oz., valued at $5865, in 1917, and was derived from the gold and copper ores of the new Pas district.

In British Columbia the production was 3,965,828 oz., valued at

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$3,837,811, against 2,655,994 oz., valued at $2,162,430, in 1917, showing an increase in quantity of 49 per cent. and in value of 77 per cent. This production includes refined silver, silver contained in smelter products, and estimated recoveries from ores exported.

The Yukon production was 48,041 oz., valued at $46,490, against 119,605 oz., valued at $97,379, in 1917.

British Columbia.—The Provincial Department of Mines estimate of gold output for 1918 shows an increase of 43,000 oz. from the 114,523 oz. in 1917. This is mainly due to the Belmont Surf Inlet mine on Princess Royal island. The yield of the Province in 1917 was abnormally low, as between 1900 and 1916 the annual total varied from 203,000 to 297,000 ounces. The reduction of copper ore by the Granby Consolidated accounts for about 20,000 oz. of gold and 400,000 oz. of silver yearly, while the Consolidated Mining & Smelting Co. recovers 50,000 oz. of gold and 1,700,000 oz. of silver from copper, lead, zinc, and silicious ores. These are half of the gold and three-quarters of the silver production of the Province. The Nickel Plate gold mine at Hedley yields 30,000 oz., and the Surf Inlet mine 36,000 ounces. The Skeena, Rossland, Coast (Southern), and Nelson districts increased in 1918, but the Boundary-Yale and Lillovet regions fell off. Placers yielded 15,000 oz., these being at Cariboo and Cassiar. The supply of water was low last year. There are undoubtedly many deposits of gold-bearing gravels in the Atlin, Cariboo, and other districts, which, under normal conditions, will yet be worked either by hydraulicking or dredging. The increased demand for gold and probably lowering of costs now that the war is over should cause renewed interest in placer-mining.

The Rossland mines, which prior to 1917 contributed annually one-half of the output of lode gold, made about the same production in 1918 as in the preceding year; during these two years one-quarter the normal output was made. The mines were worked somewhat irregularly during the first six months of the year; after that, although development was continued, only small shipments were made.

The silver output amounted to 2,887,000 oz., a decrease of 42,000 oz., but an increase of $335,000. About 75 per cent. of the total Provincial output comes from the treatment of silver-lead-zinc ores, the balance mainly from the smelting of gold-copper ores carrying silver. The Slocan district was again far in the lead of all other districts in silver production, 47 per cent. of the total being credited to it. The figures for this year indicate a decreased production for the Slocan, compared with last year, of about 12 per cent. A considerably lessened output from the Standard mine, at Silverton, accounts for some of this decrease. The largest producer in the Slocan was the Surprise, followed by the

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Queen Bess and the Standard. There were nearly 40 shipping mines in the district in 1918.

Important developments in silver are expected from the region north of Stewart Inlet and Alice Arm, where several good deposits are being exploited.

Ontario.—The gold production of this Province is mainly at Porcupine and silver at Cobalt, and their effect on the totals may be seen in the following table:

Year.	Province. Gold, Oz.	Porcupine. Gold, Oz.	Province. Silver, Oz. (a)	Cobalt. Silver, Oz. (b)
1904	1,935	.....	206,875	206,875
1905	4,402	.....	2,451,356	2,451,356
1906	3,202	.....	5,401,766	5,401,766
1907	3,212	.....	9,982,363	10,023,311
1908	3,212	.....	19,398,545	19,437,875
1909	1,569	.....	24,822,099	25,897,825
1910	3,089	1,947	30,366,366	30,645,181
1911	2,062	755	30,540,754	31,507,791
1912	85,523	83,725	29,214,025	30,243,859
1913	219,801	207,748	28,411,261	29,681,975
1914	268,264	251,131	25,139,214	25,162,841
1915	406,577	366,574	22,748,609	24,746,534
1916	492,481	452,095	21,608,158	19,915,090
1917	431,355	410,000	19,479,691	19,401,893
1918	411,879	375,806	17,409,263	17,332,804

(a) Dominion Department of Mines figures. (b) Ontario Bureau of Mines figures. The excess of the Cobalt output over that of the whole Province in some years is probably due to different methods of reporting shipments.

The outlook for gold mining in 1919 is considered to be bright. During 1918, the Porcupine yield was from 816,037 tons of ore, the Hollinger contributing 578,755 tons worth $5,706,214, the McIntyre 176,976 tons for $1,561,735, Porcupine-Crown, 10,907 tons for $123,563; Dome Lake, 11,929 tons for $100,799; Schumacher, 19,098 tons for $92,260; and Porcupine V. N. T., 15,134 tons for $82,203. Dividends were paid by the Hollinger and McIntyre, amounting to $1,773,042. The total to date is $13,359,210.

Kirkland Lake mines yielded 30,520 oz. of gold from treatment of 55,523 tons of ore. The producers were: Lake Shore, 16,749 tons for $415,230; Teck-Hughes, 14,774 tons for $79,949; and Tough-Oakes, 22,000 tons for $136,828. The Lake Shore paid $100,000 in dividends.

The Matachewan is the latest gold district to attract attention in Ontario. It is 50 miles southeast of Porcupine and 60 miles northwest of Cobalt. The region was examined by A. G. Burrows[1] of the Provincial Geological Survey. Gold occurs in quartz and schist. Exploration proceeded during 1918, and rich ore was found in pockets and to a depth of 300 feet. Capital became interested, and the Otisse, Davidson, and other properties are receiving thorough development.

[1] 27th Annual Report of Ontario Bureau of Mines, 1918.

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Boston Creek is also receiving development, where the Patricia yielded $10,000 in 1918, and telluride of gold has been found in the Miller-Independence.

Besides Cobalt, Ontario has the Gowganda silver field, which, with South Lorrain last year produced 774,403 ounces. Seven companies at Cobalt paid dividends totaling $4,696,513, making $75,518,342 to date. The silver was extracted as follows: 9,506,017 oz. from mills at Cobalt, 5,014,469 oz. from refineries at Deloro, Thorold and Welland, and 2,812,318 oz. from refineries in the United States.

According to Kirby Thomas,[1] the discovery and development of new silver districts in Ontario, particularly in the Cobalt area and in those geologically related, have not for several years kept pace with the decadence and exhaustion of the productive mines. Some new veins, and extensions of others, and improved metallurgy have prolonged production. Two widely separated and geologically different parts of Cobalt are being exploited. The Adanac in the southwest is testing the upper Keewatin-diabase contact-zone, and the Genessee and Mining Corporation are prospecting in conglomerate and in diabase, respectively, in the northwest. Then the Beaver and Temiskaming are determining the possibilities of the lower contact between the diabase and Keewatin, to a depth of 1600 feet. Results here were commercially unsuccessful. The Gowganda district is promising, but South Lorrain is about depleted.

Yukon.—This territory, like Alaska adjoining, was considerably affected by abnormal conditions during 1918. The gold yield now is less that 20 per cent. of that in 1900, the year of greatest productivity. Practically all of the metal is recovered by dredging and hydraulicking, and then by the two principal companies—the Canadian Klondyke and Yukon Gold. The table below shows what has happened in the Klondike since the boom in 1896.

GOLD PRODUCTION IN KLONDIKE

Year.	Ounces.	Year.	Ounces.	Year.	Ounces.	Year.	Ounces.
1896....	14,513	1902.....	701,437	1908.....	174,150	1914.....	247,940
1897....	120,937	1903.....	592,594	1909.....	191,565	1915.....	230,173
1898....	483,750	1904.....	507,938	1910.....	221,091	1916.....	212,700
1899....	774,000	1905.....	381,001	1911.....	224,197	1917.....	177,600
1900....	1,077,553	1906.....	270,900	1912.....	268,447	1918.....	102,382
1901....	870,750	1907.....	152,381	1913.....	282,838	.....	.....

The average value of the crude gold received at the Dominion Assay Office at Vancouver for a number of years has been $16.50 per ounce. A royalty of 2½ per cent. is payable to the Government, for which purpose all gold is valued at $15 per ounce. In October, 1918, Alfred

[1] *Min. Sci. Press*, 117, 599 (1918).

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Thompson, member of Parliament for the Yukon, asked that the royalty be removed so as to encourage gold production.

Late last year, the Yukon Gold Co., which also operates dredges in the United States, suspended dividend payments due to unexpected low returns and high costs. This company produced gold worth $2,283,862, of which $1,884,957 was by dredging, the remainder from hydraulicking. Three dredges of the Canadian Klondyke Co. dug 4,300,910 cu. yd. of 11.19-ct. gravel, and just broke even after paying all charges.

The topographical geology of dredging areas of the Yukon was fully dealt with by Charles Janin in *Bulletin* 127 of the U. S. Bureau of Mines.

Central and South America

The unfavorable position of gold left that metal comparatively neglected last year, that is, few new enterprises were started; while silver, mostly a by-product of gold and copper extraction, remained at about normal. In Honduras, the New York & Honduras Rosario; in Costa Rica, the Abangarez; in San Salvador, the Devisadero; in Colombia, the Oroville Dredging; in Nicaragua, the Eden; and in Brazil, the St. John del Rey and Ouro Preto, continued gold and silver production. A study of a combined gold table of Central and South America shows a total of $7,000,000 in 1890, $12,200,000 in 1896, and from 1904 onward the annual yields were:

1904	$11,581,000	1912	$15,806,000
1905	12,224,000	1913	14,370,000
1906	12,599,000	1914	15,002,000
1907	13,913,000	1915	17,274,000
1908	14,337,000	1916	18,706,000
1909	13,864,000	1917	17,757,000
1910	15,969,000	1918	15,000,000
1911	15,862,000		

Costa Rica.—During 1917 this country exported gold worth $971,494, and silver worth $2,547,564.

The principal gold mine in this republic is that of the Abangarez Gold Fields of Costa Rica. The report for 1917 was only issued in September, 1918, and shows the following comparison with previous years:

	1917.	1916.	1915.
Ore treated, tons	62,934	50,221	25,262
Gross yield	$636,298	$670,574	$197,619
Average per ton	10.12	13.35	7.82
Total cost per ton	7.26	8.48	8.18
Net profit	$178,733	$244,951	$9,244[1]

Interest on loans reduced the 1917 profit to $110,580. Notes payable amount to $1,143,248.

Honduras.—Deep mines in 1917 yielded 13,790 oz. of gold and 1,670,612 oz. of silver, and placer mines 11,500 oz. of gold.[2]

The most of these totals were from the New York & Honduras

[1] Loss.
[2] Annual Report of Director of Mint, 1918.

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Rosario Mining Co., which treated 125,900 tons of ore assaying 15.026 oz. of silver and 0.1165 oz. of gold per ton.

Nicaragua.—The most interesting note concerning mining in this republic was that in November the Eden Mining Co.'s mill went into permanent commission, and in January a shipment of gold was made, worth $46,000. This mine is controlled, with the Nicaragua mine, by the Tonopah Mining Co. of Nevada.

In 1917, gold exported amounted to $166,183 as bullion and $759,446 in ore; also $34,462 silver bullion and $88,998 silver in ore.

Bolivia.—Precious-metal statistics are far behind. A recent 6-year period averaged $320,000 of gold per year exported, and in 1916 the silver shipped out was valued at $1,751,850. The silver and tin-silver mines of Oruro and other districts no doubt responded to the higher price for the metal in 1918.

Brazil.—In line with the action of all other countries, the Government of Brazil, which had prohibited the exportation of gold and silver, in February, 1918, arranged with the St. John del Rey and Ouro Preto gold mining companies, both British corporations, to acquire the whole of their production. In 1917 gold exports totaled 140,000 oz., and silver, 18,000 ounces. These quantities are just about what the two mines mentioned produce, as in 1917 St. John del Rey treated 198,000 tons of ore for 110,500 oz. of gold, and Ouro Preto 85,000 tons for 30,200 ounces.

British Guiana.—There has been a gradual decrease in the gold yield of this possession during the last 25 years. In 1893, the best year, the output was 137,629 oz.; but in 1917 it was only 29,538 oz., and most likely on account of many difficulties that for 1918 will show another decline. Labor is attracted to plantations near the coast rather than to mining. The Government Geological Department has faith in the future of the industry. In 1916, dredging contributed 30 per cent., and placer operations 68 per cent. of the total production.

Chile.—This country produces about 30,000 oz. of gold and 1,200,000 oz. of silver yearly, largely from the copper mines of the Braden and Chile Exploration companies.

The method of extracting pillars in the Fortuna mine of the Braden company was described by Charles Hollister.[1] This system is a modification of that at Ray, Arizona. Tunnel-blasting at Chuquicamata was explained by E. E. Barker.[2] Blasting churn-drill holes was so costly that driving and blasting from tunnels was substituted.

Colombia.—This is essentially a platinum-producing country, its value in 1917 being about 7 times that of gold. The largest single oper-

[1] *Eng. Min. Jour.*, **106**, 478 (1918).
[2] *Min. Sci. Press*, **117**, 213 (1918).

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ators are the Oroville Dredging Co., which controls the Pato and Nechi companies working two boats in the department of Antioquia. Recent returns have not been available. The Frontino & Bolivia company treats over 20,000 tons of $17 ore yearly.

Peru.—While the output of gold is now over 60,000 oz. per annum, that of silver is over 10,000,000 oz., placing this country fourth on the world's list for the latter metal. Cerro de Pasco accounts for about half of the gold from copper ore, Backus y Johnson for a good deal, also from copper, while the Cotabambas Auraria and New Chuquitambo gold mines and alluvial workings make up the remainder. The above-mentioned copper mines yield a great deal of silver, and individual silver mines account for the balance, including the Caylbana mines, which have a mill and cyanide plant.

Venezuela.—Little data is obtainable, but the gold output is valued at under $1,000,000 a year—60 per cent. from deep mines and 40 per cent. from placers. According to C. F. Z. Caracristi[1] the gold production in 1917 was $634,170, there being 14 producing companies; in 1918 the output fell to about $472,000.

The principal gold-bearing area occupies the southwestern portion of the Republic, from the headwaters of the Yuruari down to the frontier of British Guiana, according to H. H. Miller.[2] Occurrence of gold here may be divided into three types; true alluvials, belts or zones of shale, and quartz veins. The second type is probably the source of the placer gold. The veins are mainly confined to around the old town and mines of El Callao. This property is reputed to have yielded $50,000,000 in its 30-year life. Its maximum activity was 30 years ago. Some of its mines have good prospects. The three companies operating there at present are the Gold Fields of Venezuela, El Amparo, and Anonima Minera Lo Increible. The first has two Chilean mills and cyanide plant treating ½ to ¾-oz. ore; the second is practically exhausted, but had 10 stamps and cyanide equipment; and the third has 20 stamps and has crushed 40,000 tons of ½-oz. ore and has 25,000 tons of ¼-oz. tailing or cyanidation. With better transportation facilities, dredges, and other modern gold-saving appliances, southeastern Venezuela might take front rank in the most productive regions of South America. This also applies to El Callao.

Mexico

It is generally admitted that conditions in this country are slowly, but surely, returning to a normal basis; yet mining companies are slow to resume operations at full capacity. One disturbing factor is the bad

[1] *Eng. Min. Jour.*, **107**, 438 (1919).
[2] *Min. Sci. Press*, **117**, 651 (1918).

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state of the railways. The following tables show the output of precious metals in a period of 29 years:

Year.	Gold, Value.	Silver, Oz.	Year.	Gold, Value.	Silver, Oz.
1890	$1,150,000	32,000,000	1905	$16,107,100	60,000,000
1891	1,275,000	35,200,000	1906	18,534,700	54,400,000
1892	1,400,000	39,600,000	1907	18,681,100	68,200,000
1893	1,305,000	44,100,000	1908	22,371,200	72,250,000
1894	1,463,000	46,800,000	1909	23,842,900	72,320,000
1895	5,100,000	50,890,000	1910	24,910,600	78,000,000
1896	6,310,000	41,374,000	1911	24,880,100	80,650,000
1897	7,121,000	40,800,000	1912	24,500,000	74,640,000
1898	8,236,000	42,400,000	1913	19,308,800	70,703,000
1899	9,277,000	41,700,000	1914	4,788,175	70,703,000
1900	9,409,000	43,450,000	1915	6,559,275	39,570,000
1901	10,329,316	46,910,000	1916	7,690,100	22,838,000
1902	11,293,524	49,100,000	1917	9,000,000	31,214,000
1903	10,677,500	57,400,000	1918	10,000,000	40,000,000
1904	12,605,300	49,200,000			

According to L. H. Coley,[1] industrial conditions in that country are showing material improvement since the armistice was signed. He said in part:

"There is still some interference from the lawless elements in the western districts, but not nearly so bad as for the last few years. Nearly all the mines are being worked, especially those owned by large foreign companies. Ores are being accumulated with a view to supplying the smelters with the quantity and variety of ores needed to make continuous operation possible, and the great smelters are being put in the best possible condition in anticipation of heavy business. The administration has decided that it is unprofitable for the mines to remain idle, as the taxes are needed by the Government, therefore the railroads to the mines are kept in as good condition as possible, supplies are transported with but little delay, and they are doing what they can to further production. I travel to all parts of Mexico and have not been delayed, hampered, or even insulted during all my journeys. There is considerable activity among the largest foreign mining companies in the acquisition of desirable mining properties, and any good prospect promptly receives careful examination. The British are notably active in this regard, and I take it to be a sign that they are convinced that their investments will be safe and profitable. Common laborers in the mines now receive 1.50 pesos per day and the higher class of operatives get from 3 pesos to 5 pesos per day. What the Mexican people want now is plenty of work at fair pay, and they will be contented and happy; they have had their fill of war and want no more of it. The influenza deaths (436,000) greatly interfered with mining and there is still a shortage of labor in many localities, but those who were frightened away are gradually returning."

An editorial note[2] on conditions in Mexico and whether it was safe to return thither said that such information as is available indicates that the Carranza government is settling in the saddle and is steadily establishing its ascendancy. Mining is taxed 10 per cent. on the gross output, but the cheapness of labor and the high price of silver mitigate

[1] *Min. Sci. Press*, 118, 98 (1919).
[2] *Min. Sci. Press*, 118, 174 (1919).

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the affliction. At El Oro, Pachuca, and other old centers of activity the unsettled state of the country does not hinder operations, partly because the Government needs the metals produced and the revenue derived from the British and American companies. On the West Coast there is increased activity and also news of highly satisfactory developments underground.

Under the Diaz law of 1892, which abolished the ancient obligatory development and allowed large mineral areas to be held simply by paying an areal tax of 3 pesos per hectare (60 cts. per acre) annually, the leasehold system of Mexico became as favorable for speculators as our fee-simple tenure, and by 1910 every likely district was covered with idle locations, according to R. B. Brinsmade.[1] Under the new policy of Carranza, conditions have improved for the working prospector, because under an annual areal tax varying from 6 pesos per hectare, for areas of under 5 hectares, up to 18 pesos for areas exceeding 100 hectares, coupled with the obligation of mining activity, large numbers of idle holdings are rapidly reverting to the public domain. Had the paper-money plague and the continual civil war not disorganized finance and transportation, the new legislation would undoubtedly stimulate an unprecedented mining development in this country. An article[2] entitled "Mexican Mining in 1918" sums up the present position as shown in the following extracts:

"The payment of dividends during 1918 by a number of concerns operating in Mexico, such as the Amparo Mining Co., the Greene Cananea Copper Co., the Lucky Tiger Combination Gold Mining Co., the Mexico Mines of El Oro, the Esperanza Mining Co., the Santa Gertrudis Co., the El Oro Mining & Ry. Co., and the two important American smelting companies, is an indication that conditions in some parts of the country have been better than in others. A number of other properties started operations during the period, in some instances following the blowing in of American-owned smelters in the neighborhood. The resumption of work, however, has arisen largely from necessity, coupled with a confidence in the future which was born of a hope that a return to activity on the part of the operators would engender a certain consideration on the part of the Mexican authorities. It was also hoped that Mexicans would recognize the fact that the evils existing are serious deterrents to national progress and development; and that the very existence of their own people is at stake.

Mining in the State of Tamaulipas has been at a standstill. The mountainous sections of the State are still occupied by revolutionists, and each pack-train of burros has to be convoyed by Carrancista soldiers. In addition to this, it is not possible to secure explosives with which to continue mining. Of the number of properties formerly in operation in this State, no more than 20 are now paying the Federal taxes which are required to insure a continued official recognition of ownership. Labor around the towns is abundant at from 75 centavos to 1 peso per day, with lack of employment for the poorer classes.

A gradual resumption of mining is in evidence in the States of Coahuila, Chihuahua, and Sonora, and several smelting plants are in active operation. The Mazapil

[1] *Min. Sci. Press*, **118**, 177 (1919).
[2] *Eng. Min. Jour.*, **107**, 112 (1919).

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Copper Co., which has extensive interests in Coahuila, including a small railway, smelters, and various mines, conducted successful operations, and it is expected that the favorable results will continue. The reopening of coal mines, which have been practically inactive for more than four years, was announced, and a good output for 1919 is expected. A railway is being built between Sierra Mojada and Cienegas, which, when completed, will bring a large tonnage of low-grade silver-lead ores to the smelters of Monterey. A number of mining properties in the western part of the State of Chihuahua will resume operations as soon as practicable. Regular shipments are being made from the Cusi property to the Chihuahua smelter. Plans are under way to extend the Tigre transmission line, belonging to the Copper Queen works at Douglas, Arizona, to supply power for the mill of the North Tigre mine, in Sonora, Mexico. The Carnegie Lead & Zinc Co. continued operations at its property near Cananea, Sonora. The Cia. de Minerales y Metales has obtained a lease on the Santa Eulalia property, in Chihuahua, and successful expansion is expected. The Compagnie du Boleo, operating in Baja California, continues to produce from its 1000-ton plant, and progress has been free from the interruptions common to the mainland.

In the Guanajuato district all the more important mining companies operated throughout 1918. These include the Guanajuato Reduction & Mines Co., the Guanajuato Consolidated Mining & Milling Co., the Guanajuato Development Co. (the Peregrina and San Matias units), and the Cubo Mining & Milling Co. The Guanajuato Reduction Co. operated mostly on fill ore, the Guanajuato Development Co. on fill and freshly broken material. Both used cyaniding exclusively; but a large amount of flotation experiments were carried on. The Guanajuato M. & M. Co. started the construction of a new mill in La Luz district. The Cubo company treated only freshly broken ore from its Villalpando mine at the mill of the Providencia Mining & Milling Co., which it has under lease and with an option to purchase.

In the El Oro district, the El Oro Mining & Ry. Co. made progress in increasing output in an effort to lessen costs per ton. Ore reserves have been reduced to exclude any material having a combined gold and silver content valued at less than $7 per ton. Governmental and unofficial interference hampered progress at this property, as in other districts.[1]

At the property of the Cia. de Santa Gertrudis mining operations were carried out during 1918, and the ore was sold. Developments in the mine have not added materially to the reserves. Milling operations at the Cia. Beneficiadora de Pachuca were under capacity, on account of the difficulties in the operation of the settling and filtration plant. It is expected that the installation of additional equipment will remedy the trouble. Flotation experiments were concluded, with results which showed that the process, in its present stage of development, cannot compete commercially with cyanidation for the treatment of the company's ore. Aluminium is now being used in place of zinc dust for precipitation purposes. A considerable saving is already assured, which will be increased as operations are extended.

The Amparo Mining Co., operating at Etzatlan, Jalisco, has been a constant producer and a steady dividend payer. It is reported that flotation tests have been satisfactory and that the necessary modification in the arrangement of the plant may be expected in the near future.

Little progress has been made in the opening of properties and the development of the mineral industry in the southern States. The majority of the mines remained idle throughout 1918. In many cases road and railway construction must be carried out before further development can be expected."

[1] For various reasons the company's last report contained no statement of profits, etc.

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Regarding the Amparo Co. mentioned above, the following comparative statement will give some idea as to the general increase in cost of supplies, in United States currency:

Article.	1912.	1917.
Dynamite, case	$9.90	$17.80
Cyanide, pound	0.18	0.88
Mining steel, pound	0.11	0.28
Fuse, thousand feet	3.93	7.95
Caps, hundred	0.46	1.74
Carbide, pound	0.06	0.07
White iron, pound	0.005	0.03
Coke, ton	20.00	70.50
Lumber, thousand feet	40.00	120.00
Nails, pound	0.07	0.18
Round and flat iron, pound	0.04	0.14
Cruciform steel, pound	0.11	0.30
Steel plates, pound	0.06	0.19
Steel shafting, pound	0.08	0.16
Crucibles, No. 300, each	21.00	64.88
Battery shoes, each	10.00	27.00
Battery dies, each	8.00	17.50

At Pachuca, the Santa Gertrudis recently acquired rights to El Bordo property, which is estimated to have reserves of 253,000 tons, from which a profit of $2,142,000 is anticipated. In "A Post-Mortem"[1] the results of Santa Gertrudis since 1910 were analyzed. The mine yielded dividends aggregating £731,250, on a capital of £1,500,000, of which the Camp Bird company of Colorado owns 81 per cent., for which it paid £922,131. Ore in reserve is now estimated as 880,433 tons, which should yield a profit of $3,750,000. Camp Bird will get back its principal plus about 25 per cent.

The United States Smelting, Refining & Mining Co.'s subsidiary, Real del Monte, enlarged its mills at Pachuca by 9000 tons each per month, and late in 1918 they were treating a total of 54,600 tons; they are to have an ultimate capacity of 80,000 tons. A third plant, of 15,000 tons capacity, is contemplated for the rich ore from the new vein. The ores are mainly silver-bearing.

Russia

So little information on mining is available from this country of unrest, and statistics are so unreliable, that gold mining must be dismissed in a brief review. The gold is mainly from Siberia, where at present there is much trouble. Progress may be judged from the table below:

Year.	Value.	Year.	Value.
1890	$25,484,000	1905	$22,292,000
1891	24,131,000	1906	19,496,500
1892	20,921,000	1907	26,684,300
1893	21,869,000	1908	28,052,200
1894	20,985,000	1909	32,381,300
1895	18,812,000	1910	35,579,600
1896	31,005,000	1911	32,151,600
1897	21,538,000	1912	22,199,000
1898	24,734,000	1913	24,578,000
1899	23,963,000	1914	26,503,000
1900	23,090,000	1915	28,586,000
1901	25,911,000	1916	22,500,000
1902	24,460,000	1917	18,000,000
1903	24,634,200	1918	10,000,000
1904	24,803,200		

[1] *Min. Sci. Press*, 118, 205 (1919).

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Nothing is available from the Lena Goldfields placer properties, which yield up to $8,000,000 per annum; nor from the Orsk, and other dredging companies. The article "Drilling on the Lena Goldfield," by W. E. Thorne,[1] gave a good idea of placer mining in Siberia.

The impact of Bolshevism on mining[2] in Siberia was described late in 1918 in London by the chairman of the Irtysh Corporation when addressing the annual meeting of the shareholders. This holding company, formed soon after the commencement of the war, is an outgrowth of the Russo-Asiatic Corporation, which, in 1912, acquired the Ridder concession, covering 1600 square miles, and the Ekibastus coal field in the Altai region of Siberia.

There has been built a great industry, in spite of many difficulties, so that at the end of 1916 an output of finished metals was being made from the ores mined at Ridder and smelted at Ekibastus, these two points being joined by a broad-gage railroad 90 miles long. In March, 1917, the revolution in Russia created troubles exceeding those arising from war, yet the company completed its plant for extracting the lead, silver, and gold in its ore, so that it is now prepared to deliver zinc, lead, silver, gold, and copper on the market. Under normal conditions this enterprise would have reached the productive stage earlier, but late in 1917 the deleterious effects of Bolshevist activity among the workers was apparent and the interference with operations became a severe handicap. The management decided to curtail operations gradually without exciting too much attention from the Soviets. In May the Bolshevists attemped unsuccessfully to work the Ekibastus collieries. The Bolshevists were in power for only a few months in Siberia, from February to May. In August the company resumed the production of coal at Ekibastus and in November coke was being made once more. Owing to the high local prices then prevailing this production proved extremely remunerative. The lead plant is about to be re-started, because the demand for shot is acute. It is deemed inopportune to make zinc at present, owing to the closing of outlets to the markets for that metal. The mill at Ridder will treat the old dumps and also the gold ore from the Sokolni mine, but the Ridder mine itself will not be unwatered just now.

The metal mines are estimated to contain 3,534,000 tons of ore in reserve; from this a profit of $65,000,000 is anticipated. At Ridder a concentrating mill and sulphuric-acid works are in operation. The coal mines are producing 150,000 tons per annum. At the collieries are the smelters, with a capacity of 15,000 tons of refined lead and 5000 tons of refined spelter per annum, and with more than ample capacity for extracting the accompanying precious metals.

The Kyshtim and Tanalyk corporations were more exposed to Bolshevist misrule because their properties are nearer European Russia. In December, 1917, the Kyshtim plant was "nationalized" by decree of the Soviet; it was operated by a Workmen's committee until May, 1918, when the Czecho-Slovaks routed the Bolshevist forces near the town of Kyshtim. The Provisional Government re-started operations and later placed one of the company's general managers in charge, the works themselves not having been damaged during the interregnum. The establishment is now being re-organized and the company resumes, as regards title, its former status. After such an orgy of disorder it is difficult to restore former conditions, but as the new

[1] *Min. Sci. Press*, **116**, 447 (1918).
[2] *Min. Sci. Press*, **118**, 139 (1919).

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government of Siberia becomes strengthened it will be easier to repair the normal economic life of the country. This is now being done in places. The new government has gained the support of experienced public men in the country who have hitherto been reluctant to join any of the experimental administrations. It is important to note that the Siberian Government has recognized its liability for damages and financial expropriation or loss caused by the Bolshevist regime, and when the proper time comes a claim will be preferred by the company for restitution of materials and funds expropriated by the Bolshevists. The Kyshtim enterprise is capable of producing from 12,000 to 15,000 tons of copper per annum. It has a sulphuric-acid works of 8000 tons capacity per annum, a dynamite plant of 1200 tons capacity, and a plant to produce 4000 tons of copper sulphate annually.

At the Tanalyk mines, which are in the Ural region, the production of copper, gold, and silver proceeded profitably, thanks largely to the premium obtainable in Russia for all metals, until the close of 1917. In March, 1918, thanks to the Bashkirs, the mines were freed of the anarchists and later the representatives of the provisional government of the Bashkir community-lands, with headquarters at Orenburg, established an office at Tanalyk. These agents of the new government have shown the most friendly and helpful attitude to the company. Owing to the difficulty of obtaining supplies, such as mercury and cyanide for the mill and coke for the smelter, it is not practicable to resume operations on the maximum scale, but productive work is in progress and the opportunity is being taken to push the construction of a branch railway to connect with the main line. The ore in reserve is valued at $5,000,000.

To understand events in a large country like Russia it is important to know what this country represents, according to F. F. Foss;[1] also what are the chief characteristics of the many races making up the 181,000,000 people of the Russian nation, and their general economic conditions.

As there is considerable copper, gold, iron, and platinum mining in the Ural Mountains, H. W. Turner's[2] paper on the physical geography of that range is of value to mining engineers, as was also H. C. Woolmer's general review[3] of mining in Russia.

Metallurgical Progress During 1918

As was the case in 1917, research and improvements in cyanidation last year were chemical, mainly at the end of the process—precipitation. Under that sub-head will be found a brief review of results. The relative merits of sodium and potassium cyanide are still the subject of discussion, also the use of lead salts, and crushing in cyanide and water. Graphitic schist has been a troublesome cyanicide—if it may be termed such—at Kalgoorlie and in West Africa, causing premature precipitation of gold. Now, however, the metallurgists in the latter field have found that a wash of sodium sulphide counteracts the trouble. In roasting before cyanidation, it is found with Cripple Creek ores that it is best to treat

[1] Address before Engineers Club, San Francisco, July 2, 1918.
[2] *Min. Sci. Press*, 117, 411 (1918).
[3] *Min. Sci. Press*, 117, 597 (1918).

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separately two classes carrying different percentages of lime. Improvements in melting precipitate are attracting attention. There were few mechanical betterments during 1918, what there were being in details of ball and tube mills. For concentration there is little new to say. Those who rushed into flotation of gold and silver ores have since had time to consider the advantages or otherwise of this system. There were few large plants brought into commission last year—one in California, one in Colorado, and one in Nevada. Instead of building new ones, the tendency was to shut down, owing to abnormal conditions. The abstracts following should be found useful reference.

In reviewing the metallurgy of gold and silver during 1918, *Chemical and Metallurgical Engineering*[1] considered that all the discussions on the gold industry added nothing to the metallurgical achievements of the year. Unquestionably, it said, the development of first importance was Crowe's process of precipitation in vacuo. It is:

> By this process the elimination of oxygen from the solutions at the approximate moment of precipitation is readily accomplished. The necessary apparatus is inexpensive, and the power consumption almost negligible. The resulting saving of precipitant may be as much as 30 per cent.
>
> But the various steps in the cyanide process are so inter-related that the possibilities resulting from the application of this process do not stop here. Thus, as the reduced amount of precipitant naturally leads to improvement in the grade of precipitate, we may speculate as to the probable evolution of refining methods. As we suggested a year ago, the electric furnace may appear in regular practice as a result of these changed conditions; on the other hand, the possible revivification of refining by distillation and recovery of the zinc from the precipitate seems more remote.
>
> Again, although the process benefits in a measure both zinc-dust and zinc-shaving precipitation, its effect will be to improve the relative position of the former in popular favor. Ten years ago the dust method failed of establishment in South Africa, primarily because it could not, in the then state of the art, compete with shavings in the precipitation of a very dilute solution. It seems possible that, reinforced by the Crowe process, a different verdict will be given if the case is reopened.
>
> This, too, is rendered more likely by the continuing development of American zinc dusts of superior quality. Several such dusts, regularly marketed today, are consistently better than the best Silesian dust of 1914 and earlier.
>
> Almost simultaneous with the advance in zinc-dust precipitation in America has been a successful development of charcoal precipitation by Edmands and Moore, at the Yuanmi plant in Western Australia. The precipitating action of various forms of carbon has been for many years a subject of discussion, and we believe it to be the generally accepted conclusion that the actual work of precipitation is done, not by the carbon directly, but by adsorbed gases. This view is supported by the fact that graphite is without action. The very recent campaign for peach-pits and similar shells of vegetable origin, to be coverted into charcoal for use in gas-masks, is an interesting illustration of the variation of this property in different charcoals. In the discussion of Edmands' paper before the Institution of Mining and Metallurgy, this question

[1] Vol. 20, p. 1 (1919).

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was touched upon, and it was emphasized that the successful work at the Yuanmi might have been due, in a measure at least, to the use of charcoal made from mulga—an Australian hardwood.

The precipitating action of certain carbonaceous rocks has often been a source of difficulty in cyaniding, preventing satisfactory extractions through the premature precipitation of some dissolved gold. Work by Feldtmann and Wartenweiler on West African ores has shown that such gold may be re-dissolved in sodium sulphide solutions, and an ingenious process has applied this principle. It seems to have possibilities in other localities.

The special applications of cyaniding to silver ores have experienced no additions during the year, but the work being done in Colorado, under the direction of the U. S. Bureau of Mines, will be awaited with interest. This investigation looks to the beneficiation of the manganese-silver ores, so frequent in occurrence and so generally refractory, and we understand that it offers excellent promise.

Flotation, as affecting gold and silver metallurgy, remains as it was a year ago. Mechanically, too, the year has little to record. Practically no new construction has been coming forward, and no new light has been thrown on the crushing problem. Blomfield published an able paper in discussion of Golden Cycle milling, and the data given of the performance of the bowl classifier—the latest of the Dorr machines—suggest that it will have a considerable field of usefulness.

The cyanider is interested in the future of the great nitrogen-fixation plants proposed for war purposes. He is looking to these, and perhaps also to the more serious efforts to produce cyanide from cyanamide, for a considerable reduction in the price of cyanide and for a little healthy competition in the business.

In a similar review, A. W. Allen[1] points out that cyanide consumption is being reduced to an almost unbelievable point in some plants. The results at the Victor mill of the Portland company for six months of 1917 indicate that the amount of NaCN used has been lowered to 0.175 lb. per ton of ore. This is a creditable showing, and close to the record for the City Deep plant, at Johannesburg, for the month of August, 1917, when a consumption of 0.169 lb. per ton treated was recorded. High zinc consumption usually accompanies high cyanide consumption. Economies are, likewise, usually in synchronism. The Portland company's showing of 0.191 lb. of zinc dust per ton of ore treated exhibits a considerable saving as a result of the introduction of the Crowe modification.

Mr. Allen then reviews amalgamation, African metallurgical progress, the reinstatement of charcoal as a precipitant (as covered elsewhere in this chapter), aluminium and zinc precipitation, the use of air and chlorine in refining gold bullion, and the use of sodium sulphide in cyaniding graphitic ores, in West Africa.

Chemistry

Sodium and potassium cyanide are still both used, the latter very little now, so some discussion arises occasionally. One of the recent papers was

[1] *Eng. Min. Jour.*, **107**, 92 (1919).

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by W. J. Sharwood,[1] who reviews the method of testing solutions by silver nitrate, the manner of reporting results, testing for alkaline sulphides, stability of the two salts, and poisonous character of cyanides. When testing for alkaline sulphides, it is better to prepare the solution at the moment of making the test. Regarding stability, after three years the sodium compound lost 40 per cent. of its cyanogen, whereas the potassium salt lost nearly 50 per cent.

Lead salts in cyaniding was the subject of an investigation by T. B. Stevens[2] in Western Australia. As acetate of lead became difficult to secure, substitutes were sought. Plumbites and nitrate of lead were used, and instructions were given for making the latter at the mine. Lead acetate is made by dissolving litharge in crude acetic acid. Cyanide solutions require lead salts in order to counteract soluble sulphides and to form a zinc-lead couple for better precipitation. Acetate was universally used, save at the Homestake in South Dakota, where the nitrate was favored.

Carbonaceous schist in the ore of the Prestea mine in West Africa has been a nuisance in that it caused premature precipitation of the gold dissolved by cyanide, and the company spent considerable sums in research and experimentation, according to F. Wartenweiler.[3] In 1914, W. R. Feldtmann, who had investigated the same problem at the Ashanti mine, discovered that this prematurely precipitated gold was soluble in an alkaline mono-sulphide, preferably sodium sulphide. The ore is crushed, and divided into concentrate, sand, and slime. The first product is roasted and cyanided; the second is cyanided and then treated with sodium sulphide; the third is also cyanided, and the sodium sulphide may be used there also. The sulphide solution is applied to the charge in the leaching-vats as the second 80 tons of weak cyanide wash, and the process only adds 8 hr. to the treatment cycle. A charge of 240 tons assays $2.88 before treatment; after cyanidation the residue is worth $1.44; but after sodium sulphide it assays only 88 cts. per ton. Precipitation of gold is effected by passing the effluent Na_2S through boxes filled with copper shaving, in similar boxes to those used for zinc. Little copper goes into solution. The consumption of Na_2S is 1.2 lb. per ton of sand treated. Precipitation on aluminium was tried, but this metal is too easily soluble in strong Na_2S solutions; but an alloy of 50 per cent. Al and 50 per cent. Zn was a good precipitant.

Just as in the same district, on similar ore, one mill may concentrate and the other grind the mineral to slime with the gangue, so there will be found one mill crushing in water and another in cyanide solution. Waihi,

[1] *Jour. Ind. Eng. Chem.*, **10**, 292 (1918).
[2] *Monthly Journal Chamber of Mines*, Kalgoorlie, May, 1918.
[3] *Bull. Inst. Min. Met.*, London, July 25, 1918.

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New Zealand, is an instance of the former, and Porcupine, Ontario, is an instance of the latter practice. Milling in cyanide solution is discussed by A. W. Allen,[1] who sums up as follows:

Advantages.—(1) The milling and re-grinding plant offers exceptional advantages for the solution of gold and silver by reason of the intimate contact between metal and solvent. (2) A saving in water consumption may be effected by milling in cyanide in cases where the settlement of the ore is difficult; where the de-watering units are ineffective; or where the residue is being discharged at under 20 per cent. moisture. And (3) a simplification of plant arrangement is possible, and separate return-pumping and storage systems for solution and water are unnecessary.

Disadvantages.—(1) Decrease in amalgamation efficiency where this recovery method is practised; corrosion of plates; and increased consumption of mercury. (2) Higher cyanide consumption and longer time required to effect a lower extraction of the metal in the ore. (3) Increase in the amount of metal-bearing solution in circuit, with greater liability for mechanical loss; and proportionately higher precipitation costs per ton milled. And (4) liability of neglect in milling and grinding plant operation on account of the poisonous nature of the diluent.

Applicability.—(1) When no advantage, either economical, metallurgical, or chemical, arises from the use of a preliminary alkaline treatment of the ore or the water used for milling purposes. (2) When amalgamation, if adopted, would result in an inappreciable saving. (3) When it is not necessary to grind fine or slime the ore preparatory to cyanidation, thus obtaining a product which, in residue form, usually contains more moisture than if coarser crushing, followed by leaching, had been adopted. And (4) when de-watering prior to cyaniding, to within a small percentage of the amount of moisture to be discharged in the residue, is impracticable.

Amalgamation

Economies in amalgamation were detailed by S. A. Pearce,[2] who said that the chief losses of mercury are caused by the attrition of the ore particles passing over the amalgamated plates. Impure water, inadequacy of traps, too much quicksilver, and too much velocity for pulp, also result in losses. He deprecated the use of cyanide when dressing plates.

A large plate-area is needed when from 68 to 72 per cent. of the total gold in an ore can be saved by amalgamation, according to H. Ward;[2] that is, from 1¼ to 1½ sq. ft. of plate per ton crushed. The loss of mercury should not exceed 0.1 oz. per ton. It is bad practice to pass as much gold as possible to the cyanide plant. If plates are properly dressed, no steaming is necessary at clean-ups.

Grease tables are used for saving diamonds at Kimberley, and H. A. White[2] considered the possibility of trying it for gold. Some tests were made on a working-scale, and the grease plates caught from 6 to 28 per cent. of the gold expected.

[1] *Met. Chem. Eng.*, **18**, 515 (1918).
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*

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As an amalgamator, and for cleaning-up, the Berdan pan finds a fairly wide use in Australia, but not in America; however, this does not mean that the machine is useless. A. W. Allen[1] gives a few illuminating remarks on the pan. It consists briefly of a cast circular trough 5 ft. in diameter, 15 in. deep, lined, with a fixed drag, and driven either from above or below by gearing and spindle. It is set at an angle of about 30° from vertical. In the bowl is placed quicksilver, amalgam, concentrate, middling, or rich ore to be cleaned, ground, or amalgamated, as the case may be. The operation is with continuous overflow or in charges, and results are good.

The loss of quicksilver in stamp-mills is a favorite subject, and W. J. Sharwood[2] adds to it by tabulating the losses in large plants throughout the world, and citing authorities. The gold content of an ore is of course a factor in consumption of mercury, also the skill in dressing and cleaning plates and retorting amalgam. At the Homestake the average loss is 0.132 oz. per ton of ore crushed, at the Alaska United 0.077 oz., at the Bunker Hill 0.30 oz., at the North Star 0.8 to 1 oz., at the Liberty Bell 0.125 oz., on the Rand 0.035 oz., and at Bendigo 0.38 oz. per ton.

The consumption of mercury in a Huntington-mill plant at La Luz, Nicaragua, has averaged 0.144 oz. per ton of ore milled, according to H. G. Smith.[3]

P. T. Bruhl[4] described amalgamation and roasting practice at the Prestea Block A, West Africa. Gold was caught on 22 side-shaking plates, making 180 strokes per minute, driven by a 10-hp. motor. Ammonium chloride and sand are used to remove stains on the copper plates; then mercury is rubbed on. Cyanide is not objectionable for cleaning plates, and as the battery water contains a little cyanide they become bright and the amalgam hard. Just enough quicksilver is added to plates to keep them soft, and a thin layer, $\frac{1}{16}$ in., of amalgam is sufficient. In cleaning-up, the plates are steamed, then scoured with sand, and rubbered; but they should not be scoured too clean. Amalgam is all cleaned in a Berdan pan before squeezing and retorting. Concentrate from the mill is roasted in Edwards furnaces, using wood fuel. The roasted product is ground in 0.5-per cent. solution in four Bigelow pans, 81.38 per cent. passing 200 mesh. The pulp is agitated for 70 hours, then washed in a Dehne filter-press.

Regarding mercury, it is not out of place here to mention the excellent work—*Bulletin* 78, "Quicksilver Resources of California," by W. W. Bradley of the California State Mining Bureau—published in January,

[1] *Eng. Min. Jour.*, **106**, 1075 (1918).
[2] *Min. Sci. Press*, **116**, 483 (1918).
[3] *Min. Sci. Press*, **117**, 514 (1918).
[4] *Eng. Min. Jour.*, **105**, 367 (1918).

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1919. In the 389 pages will be found much of interest to those who amalgamate in their mills.

Flotation

Little progress was made in the flotation of gold ore during the year, and the newer but less complete process is now considered unlikely to become a serious rival to established methods of treatment, according to A. W. Allen.[1] The major tonnage of gold ores is treated by a leaching process, and the substitution of flotation would probably necessitate additional reduction plant to insure a finer product than is now economically practicable. There is, however, a possibility for the introduction of flotation for the concentration of the residue from some cyanide mills treating gold ore, in the same manner as has been found beneficial in Canada. In the few instances where the tailing from amalgamation plants is too refractory for cyanide treatment it has been shown that flotation may be adopted with a fair chance of success.

Flotation at Cobalt, Ontario, passed the experimental stage in 1918, and published results show that it has almost completely displaced gravity concentration. Various questions of comparative economy have arisen, and in some instances it was considered preferable to sacrifice extraction to insure a high-grade concentrate, and so evade high marketing expenses. The majority of the producers depend on United States smelters to absorb their products, but charges have been excessive. At the Nipissing plant, however, the difficulties encountered in treating the concentrate successfully, coupled with the alternative expense of shipping it, led to the abolition of flotation early in 1918, and the reinstatement of the practice of gravity concentration, followed by cyanidation of the product.

Flotation *vs.* cyanidation—the economic side of the question—is practically what E. J. Atckison[2] discussed in his article on flotation of semi-oxidized silver ore at the Amparo mine in Mexico. For a while, cyanide was at a high price, and flotation was tried to lower costs. Feed to the flotation plant consisted of 90 per cent. through 150 mesh. Sodium sulphide was used for sulphidizing the ore. The position was this: recovery by flotation was a little less than extraction by cyanidation, but the former system would produce 7 tons of concentrate per day against 1 ton by the latter. Freight and treatment (smelting) of concentrate is $19.22 per ton, less $5 for premium on lead in the product, and the flotation cost per ton of ore would be $3.41. Cyanidation costs $3.92 per ton, including all charges. Therefore flotation has the advantage of 51

[1] *Eng. Min. Jour.*, 107, 98 (1919).
[2] *Min. Sci. Press*, 116, 575 (1918).

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cts., but cyanide at a normal price of 35 cts. per kg., with 1 per cent. higher extraction, would more than make up the difference. And to change the present plant to all-flotation would cost $40,000. Success of flotation is seemingly determined by local treatment of the concentrate. Flotation oils retard cyanidation materially, and a gasoline wash before cyaniding was effective. And since the consumption of cyanide was practically the same in treating the flotation concentrate as in treating the ore, the question of cyaniding the flotation concentrate puts one where he was at the beginning as regards the cyanide. So with normal prices for cyanide, flotation is not an economic factor.

Grinding for Cyanidation

The fine-grinding cyanide plant of the Barnes-King Development Co., near Marysville, Montana, was briefly described by J. H. McCormick.[1] The mill was designed to treat ore from the Piegan and Gloster mines.[2] The ore, from 1914 to the end of 1915, assayed $7 per ton in gold and silver, the ratio of weight being 1 oz. Au to 7.56 oz. Ag. The treatment extracted 90 per cent. of the gold and 59 per cent. of the silver, of which 20 per cent. was by amalgamation, 2 per cent. by concentration, and 78 per cent. by cyanidation. The cost was $1.48 per ton. In 1916 ore from the Shannon mine had to be treated, this being different from the Piegan-Gloster, nearly double the value, and 93 per cent. of the value was in gold. The former method of leaching was altered to all-sliming, as shown in the accompanying flow-sheet. Although re-arranged for capacity of 150 tons daily, with 60-hr. treatment, over 200 tons have been treated for 10-day periods. Amalgamation and concentration were abandoned late in 1916. The feature of the plant is the use of slow-speed Chilean mills for crushing the product of coarse breakers. These mills make a remarkable reduction, but leave some fine sand to be slimed in the tube mills. On account of frequent and difficult repairs the machines are not popular with the attendants. Crushing costs, however, are rather less than in larger plants using ball mills. The final classifier overflow—that is, after Chilean mills and tube mills—shows 72.4 per cent. through 200, 12.4 between 150 and 200, and 9.9 per cent. between 100 and 150 mesh. The Chilean gives a product of which 43.1 per cent. is below 200, 7.5 between 150 and 200, 10.2 between 100 and 150, 13.8 between 65 and 100, 11.4 between 48 and 65, and 14 per cent. between 20 and 49 mesh. In 1918 there was 97 per cent. of the gold recovered and 83.2 per cent. of the silver, at a cost of $2 per ton, against $1.64 in 1917.

[1] *Bull. Am. Inst. Min. Eng.*, **140**, Aug., 1918; *Trans.*, **60**, 98.
[2] This company in 1918 produced gold worth $681,568 from 69,916 tons of ore, of which the mill described treated 41,386 tons for 93,480 oz. of gold.

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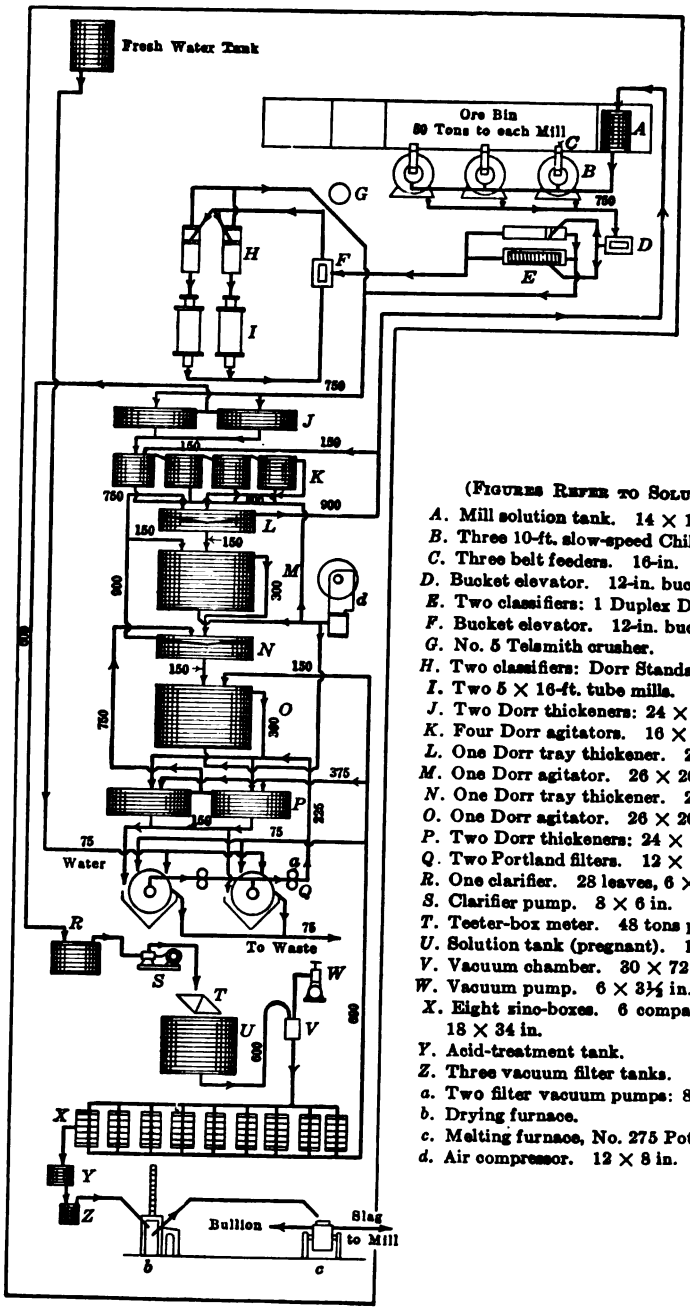

(FIGURES REFER TO SOLUTION TONNAGE)

A. Mill solution tank. 14 × 16 ft.
B. Three 10-ft. slow-speed Chileans.
C. Three belt feeders. 16-in.
D. Bucket elevator. 12-in. buckets.
E. Two classifiers: 1 Duplex Dorr; 1 Akins.
F. Bucket elevator. 12-in. buckets.
G. No. 5 Telsmith crusher.
H. Two classifiers: Dorr Standard.
I. Two 5 × 16-ft. tube mills.
J. Two Dorr thickeners: 24 × 7 ft. & 26 × 10 ft.
K. Four Dorr agitators. 16 × 14 ft.
L. One Dorr tray thickener. 26 × 10 ft.
M. One Dorr agitator. 26 × 20 ft.
N. One Dorr tray thickener. 26 × 13 ft.
O. One Dorr agitator. 26 × 20 ft.
P. Two Dorr thickeners: 24 × 7 ft. & 29 × 7 ft.
Q. Two Portland filters. 12 × 12 ft. & 12 × 10 ft.
R. One clarifier. 28 leaves, 6 × 8 ft.
S. Clarifier pump. 8 × 6 in.
T. Teeter-box meter. 48 tons per cycle.
U. Solution tank (pregnant). 16 × 16 ft.
V. Vacuum chamber. 30 × 72 in.
W. Vacuum pump. 6 × 3½ in.
X. Eight zinc-boxes. 6 compartments each, 18 × 18 × 34 in.
Y. Acid-treatment tank.
Z. Three vacuum filter tanks.
a. Two filter vacuum pumps: 8 × 8 in. & 8 × 6 in.
b. Drying furnace.
c. Melting furnace, No. 275 Pot.
d. Air compressor. 12 × 8 in.

FIG. 3.—Flow-sheet of Gloster Mill, Barnes-King Development Co., near Marysville, Mont.

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Cyanide consumption is 0.77 lb. per ton, and zinc shaving 0.85 lb. The average wage is $4.70 per shift.

Roasting

The paper[1] of A. L. Blomfield and M. J. Trott, entitled "Roasting for Amalgamating and Cyaniding Cripple Creek Sulpho-telluride Gold Ores," mostly considered the chemical phases of the processes. The Golden Cycle custom plant at Colorado Springs treats these ores exclusively, which contain practically no deleterious minerals. After sampling,

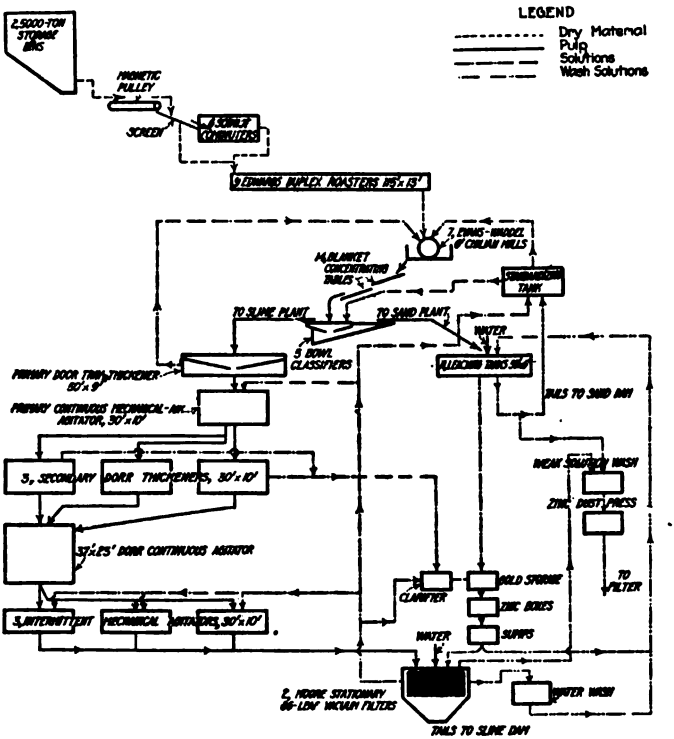

Fig. 4.—Flow-sheet of Golden Cycle Mill, Colorado Springs, Colo.

the ores are dumped into storage-bins, where beds of 5000 tons are made to ensure a good mixture. Two classes are arranged: one carrying 86.7 per cent. insoluble and 1.57 per cent. lime, the other 75.9 per cent. insoluble and 5.12 per cent. lime, both with 1.8 per cent. sulphur. Crushing is done in Schmidt ball mills, giving a product of which 13.6 per cent. passes 200, 10.2 through 30, 26.2 through 20, and 16.6 per cent. through 10 mesh. Basic ores require finer crushing than the silicious; not more

[1] *Bull. Am. Inst. Min. Eng.*, 140, Aug., 1918; *Trans.*, 60, 118.

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than 30 per cent. should be coarser than 10 mesh. Roasting is done in Edwards duplex furnaces with a live floor-area of 1495 sq. ft., and 54 rabbles traveling at 6 r.p.m. It takes 6 hr. for the ore to pass through the furnaces. Coal is used for fuel. Each furnace roasts from 125 to 150 tons of the first class and 80 to 100 tons of the second class of ore per day. The dust loss is only 0.4 per cent. by weight of the ore. The authors then ably discuss the chemical reactions in roasting silicious and basic ores, formation of cyanides, methods of analysis for sulphur in ores, and the alterations made in the plant in 1915 to accommodate the basic ores. Amalgamation was performed in two arrastras and a grinding-pan. Chilean mills grind the roasted ore, the Dorr bowl-type classifier producing a product of which all passes 100 and not over 12 per cent. remains on 200 mesh, for the slime plant, while for the leaching plant the sand must be free from colloids. Finally, the authors discuss the relative efficiency of treating roasted ores in an all-sliming plant or in a combination of sliming and leaching, as at the Golden Cycle. The deciding feature lies in the possibility of consistent efficient classification. If this is poor, advantages are with all-sliming; if good, the combination plant has the advantage.

This paper was discussed by J. M. Tippett,[1] who compared the Edwards furnace with other types, the mixing of the ores, and the low sand residue, indicating good roasting and classification.

Agitation

The automatic separation of solution from solids in the hydro-metallurgical treatment of ore-pulps was briefly discussed by Bernard MacDonald,[2] who has specialized in this problem, particularly in his Parral system of agitation. This method is analogous to the counter-current system, but is different physically in that it is carried on through a series of tanks on practically the same level (6 in. difference between each tank), continuously and automatically, by hydrostatic pressure and gravity-flow, without the aid of intervening pumps or elevators, at the same time that agitation is being carried on in the same tanks. Agitation is effected by air-lifts, which transfer the pulp from the bottom of the tank and spout it horizontally on top of the charge. This maintains a rotary flow throughout the charge, thus permitting the transfer from one tank to another.

Calculations in the design of a continuous agitation plant and in extraction therein are generally considered difficult, and this idea is in no way dispelled by the mathematical formula presented by Andrew Ham and H. S.

[1] *Bull. Am. Inst. Min. Eng.*, **143**, Nov., 1918; *Trans.*, **60**, 131.
[2] *Bull. Am. Inst. Min. Eng.*, **139**, July, 1918; *Trans.*, **60**, 107.

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Coe.[1] The first part of the paper, by Mr. Ham, is on the relation between the efficiency of continuous and intermittent agitation; that is, to determine the "detention" or treatment period which different percentages of the material have had on leaving a continuous-agitation system. In the second part of the paper, Mr. Coe discusses the applications of Mr. Ham's formula. It would appear that the technicalities involved are so many that the practical cyanide man would not bother with the problems, important though they may be.

Filtering

As in agitating there are the intermittent and continuous systems, so in filtration there are similar systems, the later type having rather the advantage in cost and scope. The filter-press is still used in America, Australia, and other mining countries for separating solution from solids in ore-pulp and in precipitating gold and silver on zinc dust; also in some of the chemical industries. The parts of the apparatus and its complete operation were fully described by D. R. Sperry.[2] The commercial uses, advantages over other types, filling and washing, details of plates and frames, etc., were covered.

Filter (Oliver type) adjustments at the Nevada Packard mill at Rochester, Nev., were described by F. D. Bradley.[3] The main trouble was erratic assays from hand-sampling of the residue from the filter, indicating only fairly good to low extraction. A mechanical sampler was devised, thus overcoming the personal element in such work. To reduce dissolved losses, barren solution from the precipitation presses was sprayed on the cake on the filter.

Leaching and filtration nomenclature—such as "percolate," "leach," "lixiviation," "clarifier," "filter," "filtration," "filter-press," and "vacuum-filter"—was analyzed by A. W. Allen,[4] who considered that the difference in meaning of these terms is not always recognized.

Precipitation

In the recovery of gold and silver from cyanide solutions, it would seem that although zinc shaving would hold its own at most plants—especially when sheet zinc is low in price—experiments and actual operations more and more favor zinc dust and aluminium dust, and most recently, merrillite, while charcoal is again attracting much attention.

Zinc-shaving installations are universal; zinc dust is used as a precipitant at 80 large mines throughout the world, but mostly in North America

[1] *Chem. Met. Eng.*, **19**, 663 (1918).
[2] *Met. Chem. Eng.*, **19**, 140, 258, 362, and 520 (1918).
[3] *Eng. Min. Jour.*, **106**, 207 (1918).
[4] *Eng. Min. Jour.*, **106**, 990 (1918).

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and Mexico, and on varied ores; aluminium-dust consumption is certainly increasing, starting at Cobalt, Ontario, and spreading to Mexico and Honduras; merrillite is used at a few mines from British Columbia to Mexico; and charcoal finds renewed favor in Western Australia and Rhodesia.

The merrillite people say that their powder is much finer than zinc dust, thus giving, weight for weight, a larger surface exposed to chemical action; and 100 lb. of it has the same precipitating effect as 115 to 130 lb. of commercial zinc dust.

Regarding aluminium dust, a report from the Santa Gertrudis company at Pachuca, Mexico, dated November, 1918, states that "aluminium-dust precipitation has proved entirely successful, and has been permanently adopted in place of zinc dust."

The last annual report of the New York & Honduras Rosario Mining Co. in Honduras contained the following remarks:

"Chemicals used were 2.463 lb. of sodium cyanide, 0.917 lb. of zinc dust (on 18,650 tons), 0.306 lb. of aluminium dust (on 107,250 tons), 1.912 lb. of soda ash, 0.009 lb. of lead acetate, and 17.878 lb. of lime per ton. The increasing cost and scarcity of cyanide made it imperative that a means be found whereby less of this chemical be used, at the same time not decreasing the extraction. The substitution of aluminium dust for zinc dust as a precipitant seemed to solve the difficulty, as it is well known that under certain conditions a good deal of cyanide is regenerated when aluminium is used.

In comparing the cyanide consumption since the aluminium process was adopted with that of the year 1915, when zinc was used entirely, an average saving of 1.215 lb. per ton of ore is shown. As 107,250 tons of ore has been treated under the new process, 130,309 lb. of cyanide has therefore been conserved. Using the latest cost of cyanide, aluminium, zinc, and soda ash as a basis, there is a saving of 38 centavos (17.5 cts.) per ton, and as the decrease of lime consumption from 29.7 lb. per ton (when zinc dust was used) to 17.9 lb., is almost entirely attributable to the adoption of aluminium precipitation, a further saving of 20 centavos (9.2 cts.) per ton has been effected, which in all makes a total saving of 58 centavos (26.7 cts.) per ton. Improvement in two directions presented itself in connection with the aluminium process: first, a saving in aluminium dust; second, the further prevention of incrustation by calcium aluminate in the mill-piping. Melting the precipitate into doré bullion continues to be the practice. Since aluminium precipitation was adopted more fluxing materials are necessary, but the bullion produced is consistently finer, therefore the extra cost of flux is somewhat offset. As precipitate by aluminium weighs considerably less than an equal volume produced by zinc, it is now even more advantageous to do the melting in Honduras instead of shipping the precipitate, in spite of increased cost in materials."

"The Inflammability of Aluminium Dust" was the title of Technical Paper 152 of the U. S. Bureau of Mines, by Alan Leighton. Users of this material have doubtless read of explosions during the grinding of aluminium, and may have had experience with fires.

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The dust burns quietly when in a pile, but if the pile be disturbed in such a manner as to raise a cloud of the dust into the air, the burning takes place with explosive violence. If a dust-cloud already formed that has a density within the explosive limits be ignited, a violent explosion results. Water is worse than useless in extinguishing fire in aluminium dust; it is positively dangerous. The fire may be smothered by sand or oil, carbon tetrachloride being used to put out the oil later on.

The Crowe vacuum precipitation process was mentioned in the general reviews of metallurgy in this chapter. It is the invention of T. B. Crowe, metallurgist for the Portland Gold Mining Co., Colorado. Since its first trials in 1917, ten large plants, operating under widely differing conditions, are said to have proved conclusively its advantages, namely, preventing the detrimental effects of any precipitating method that allows zinc or other precipitant to come into contact with cyanide solutions in the presence of air, or under conditions that in any way permit oxidation. In the Merrill zinc-dust process, the precipitant first comes into contact with the cyanide solution in the suction-pipe leading to the precipitation pump; the mixture thereafter is not exposed to the air until the press is opened for clean-up. All hydrogen generated creates a reducing condition. The Crowe process carries this principle still further, and, briefly, consists of removing from the solution, just prior to precipitation, substantially all of the dissolved air and oxygen. It is considered that the formation of the "white precipitate" in zinc-boxes at Rand mills could be eliminated by the Crowe system. In this, the oxygen is removed by exposing a stream of finely divided solution to the action of a vacuum within a suitably constructed receiver. The time of contact is short. A receiver, 6 ft. in diameter and 12 ft. long, connected with a vacuum-pump consuming under 1 hp., has a capacity of 3000 tons per 24 hours, or 500 gal. per min. The operation is continuous and requires almost no attention. At the Homestake mills a saving of 37 per cent. of the zinc dust is reported by using the Crowe process, 5 cents per ton of ore treated at the Independence mill of the Portland company, and 0.1 lb. of dust per ton of solution at the Golden Cycle mill. Mr. Crowe briefly described[1] his process at the Colorado meeting of the American Institute of Mining Engineers in September, and it was discussed by J. V. N. Dorr, A. L. Blomfield, G. T. Hansen, G. M. Taylor, and G. H. Clevenger.[2]

In MINERAL INDUSTRY, **26**, 290 (1917) mention was made of the successful work of H. R. Edmands in using charcoal as a precipitant at the Yuanmi mine in Western Australia. For the Institution of Mining

[1] *Bull. Am. Inst. Min. Eng.*, **140**, Aug., 1918; *Trans.*, **60**, 111.
[2] *Bull. Am. Inst. Min. Eng.*, **143**, Nov., 1918; *Trans.*, **60**, 115.

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and Metallurgy he prepared a somewhat similar paper[1] to that published in Australia in 1917. This led to some discussion in which[2] A. W. Allen analyzed the whole question as viewed by Morris Green, O. C. Ralston, W. R. Feldtmann, H. K. Picard, and F. Wartenweiler. Mr. Allen dealt with the theory that recent research work in connection with the precipitation of gold or a gold compound by charcoal seems to have centered around a determined effort to prove that carbon-monoxide gas is the cause. In another journal[3] Mr. Allen discussed the Moore-Edmands process. He thought that the sole drawback was the quantity of charcoal requiring reduction to bullion. Large tilting furnaces would be the best method of melting the precipitate.

Zinc-box practice was another of those practical papers by A. W. Allen.[4] Precipitation of gold from cyanide solutions by zinc shaving is generally so simple, and the bullion so good, that this precipitant is likely to hold its own. The cells of zinc-boxes must be dressed with care, and the flow of pregnant solution must not be too rapid. Some boxes are poorly designed for rapid clean-up. The hints given in these notes are worth filing.

Melting

While the graphite crucible, tilting, and the double-chamber types of furnaces are used for melting precipitate, those who have cheap power available should study the results[5] obtained from the 1000-lb. electric furnace in use at the Philadelphia Mint. The Denver and San Francisco mints are to be equipped with similar furnaces, while Philadelphia is to have others and one of one-ton capacity. The most refractory alloy reduced—cupro-nickel—costs only $9.45 per ton to melt, less than 50 per cent. of the cost in gas and crucible furnaces. In melting 10,031,101 oz. of silver, it took only 60 min. to reduce 1000 lb., consuming 198 kw.-hr. per net ton.

As mentioned above, there are several types of furnaces for reduction of gold and silver precipitate from cyanide works. The choice is often dependent upon local and economic conditions. An instance of this is seen in the paper by K. A. Cunningham and Arthur Feust,[6] who were at the Mexican M. & T. Co.'s mine in Guanajuato, Mexico. During 1918 the United States Government placed an embargo on the exportation of graphite crucibles. This forced the Mexican metallurgists either to sell their precipitate to smelters, or reduce it in oil-fired tilting furnaces, or in

[1] *Bull. Inst. Min. Met.*, Mar., 1918.
[2] *Bull. Inst. Min. Met.*, Nov., 1918.
[3] *Eng. Min. Jour.*, **106**, 256 (1918).
[4] *Eng. Min. Jour.*, **106**, 1017 (1918).
[5] Annual Report of Director of the Mint for 1918–19.
[6] *Min. Sci. Press*, **117**, 621 (1918).

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reverberatory furnaces. Details of the practise can be found in the metallurgical section of the Lead chapter, under the heading "Smelting Cyanide Silver Precipitate."

Extraction

The distinction between extraction and recovery is often ambiguous, obscuring the net economic result and rendering the disseminated information valueless, so A. W. Allen[1] defines and limits the use of these terms. He summarizes by saying that (1) the final product of metallurgical treatment should be estimated and reported as a recovery in percentage of the original content of the ore, when the yield is refined metal; and (2) when metallurgical operations are incomplete, and a concentrated but not a refined product is obtained, the metal content should be reported as an extraction, also in percentage of the original content of the ore. With this, the writer of this chapter in The Mineral Industry disagrees, and would report in just the reverse.

Description of New Mills

Crushing and cyanidation in the Prestea Block A mill, West Africa, were detailed by P. T. Bruhl.[2] The 110 1250-lb. stamps are driven by six 70-hp. motors. Ten-mesh screens are used. The pulp passes to 16 Cobbe-Middleton pans, each being driven by a 70-hp. motor. Gold is saved in these by amalgamation. The principle of this pan is that instead of the muller grinding on the dies by its own weight, it is fixed, the dies being adjustable by weights, always keeping a constant pressure. An average sizing test is as follows:

Mesh.	Feed, Per Cent.	Discharge, Per Cent.
On 30	25.82	2.64
On 60	22.27	34.37
On 90	12.15	16.51
On 120	4.95	6.19
Through 120	34.80	40.28

During the leaching of the sand, in a cycle of 5½ to 6½ days, strengths of solution are 0.25, 0.15, and 0.08 per cent. KCN. Graphite causes premature precipitation of the gold. In cyaniding raw concentrate with 0.5-per cent. solution, the extraction on a $40.80 product is up to 87.9 per cent.; and on $45 roasted concentrate, with same strength of solution, the extraction is 93.7 per cent. The white labor staff is paid a total of $5085 per month, and the natives $4109.

One of the comparatively new silver-gold mines of the West is that of the Elko Prince Mining Co., in the Gold Circle district, 55 miles west of Battle Mountain, in Nevada. The mine and mill were written up by J. V. N. Dorr and L. D. Dougan.[3] A characteristic analysis of the ore

[1] *Eng. Min. Jour.*, **106**, 740 (1918).
[2] *Eng. Min. Jour.*, **106**, 54 (1918).
[3] *Bull. Am. Inst. Min. Eng.*, **140**, Aug., 1918; *Trans.*, **60**, 78.

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shows 85 per cent. silica, 0.1 sulphur, 4 lime, a trace of manganese, 10 oz. of silver, and 0.7 oz. gold per ton. The extraction is up to 87.1 per cent. of the silver and 97.5 per cent. of the gold. Treatment is fairly simple. Although the ore is a hard quartz, a variable amount of slow-settling gouge goes with it, so that a large settling-area was needed. As the flow-

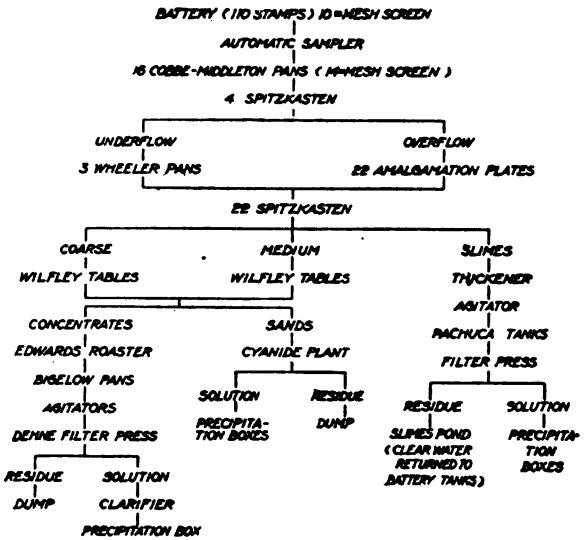

FIG. 5.—Flow-sheet at a West African mill.

sheet depicts, the main features of the plant are ball mill and tube mills, counter-current decantation, and zinc-dust precipitation. The Marcy mill, with a load of 2200 lb. of balls, reduces 2-in. feed to ¼ in. at the rate of 54 tons daily at a cost of 20 cts. per ton. The tube mill reduces this so that 65.1 per cent. passes through 150 to 200 mesh. The closed-type Dorr tray thickener is used, each doing the work of two ordinary thickeners, thus cutting the settling-floor space by half. The following table shows the rate of solution of metals in the different apparatus:

Unit.	Gold, Per Cent.	Silver, Per Cent.
Tube mill	80.0	48.3
Thickener No. 1	3.5	8.2
Agitator No. 1	9.0	22.2
Agitator No. 2	2.0	3.1
Thickener No. 2	0.7	0.8
Agitator No. 3	0.8	3.0
Thickener No. 3	0.6	0.2
Thickener No. 4	0.3	0.5
Oliver filter	0.6	0.8
Total	97.5	87.1

The total consumption of cyanide is 1.1 lb. per ton of ore, 0.6 lb. of which is mechanical. There is used 11.71 lb. of lime, 1.08 lb. of zinc, and 0.44

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lb. of litharge. Zinc dust from Colorado, merrillite, and the Crowe precipitation system have been tried, the last resulting in a 50-per cent. saving of zinc dust. Total milling costs were $3.022 per ton. The plant, built in 1915, cost $80,303.

The mine of the Belmont Surf Inlet company on Princess Royal island was responsible for increasing the gold output of British Columbia in 1918, having produced 43,000 oz. Its ore, a hard white quartz and sul-

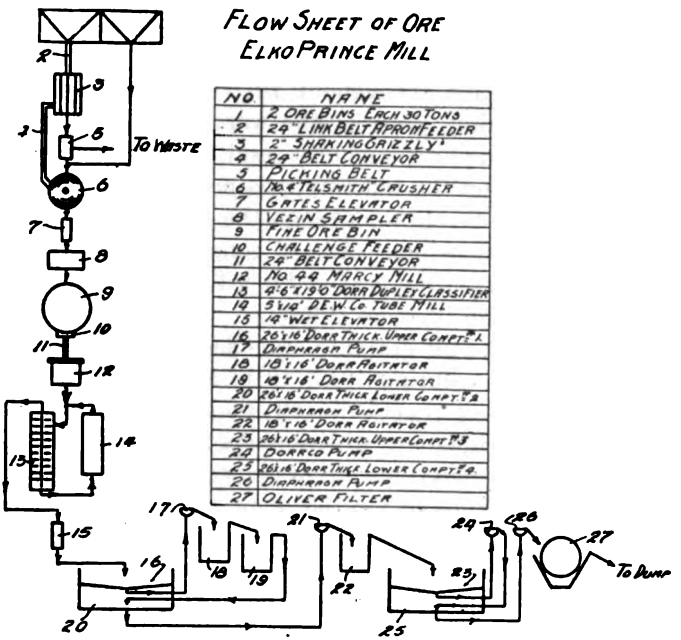
FLOW SHEET OF ORE
ELKO PRINCE MILL
NO. NAME
1 2 ORE BINS EACH 30 TONS
2 24" LINK BELT APRON FEEDER
3 2" SHAKING GRIZZLY
4 24" BELT CONVEYOR
5 PICKING BELT
6 10x8 TELSMITH CRUSHER
7 GATES ELEVATOR
8 VEZIN SAMPLER
9 FINE ORE BIN
10 CHALLENGE FEEDER
11 24" BELT CONVEYOR
12 NO. 44 MARCY MILL
13 4'6"x19'0 DORR DUPLEX CLASSIFIER
14 5'1/2" D.E.W. CO. TUBE MILL
15 14" WET ELEVATOR
16 26'x16' DORR THICK. UPPER COMPT. #1
17 DIAPHRAGM PUMP
18 18'x16' DORR AGITATOR
19 10'x16' DORR AGITATOR
20 26'x16' DORR THICK LOWER COMPT. #2
21 DIAPHRAGM PUMP
22 18'x16' DORR AGITATOR
23 26'x16' DORR THICK. UPPER COMPT. #3
24 DORRCO PUMP
25 26'x16' DORR THICK LOWER COMPT. #4
26 DIAPHRAGM PUMP
27 OLIVER FILTER
To Waste
To Pump

FIG. 6.

phides, carries 0.501 oz. of gold, 0.354 oz. of silver, and 3.888 lb. (0.194 per cent.) of copper, according to the last annual report. Flotation, using the Jones-Belmont machine, is partly used for recovery, and tests and the process were described by A. H. Jones.[1] Eight methods were tried before the present flow-sheet was finally designed. This work led to the development of the Jones-Belmont machine mentioned. The process briefly is gravity concentration, followed by re-grinding and flotation, which recover 47.8 and 44.4 per cent., respectively, a total of 92.2 per cent. The flotation ingredients are 0.01 gal. of pine-oil, 0.185 gal. of coal-tar, 0.105 gal. of creosote, and 0.15 lb. of sodium sulphide. Table concentrate contains 5.36 oz. of gold and flotation concentrate 8.2 oz. per ton.

[1] *Eng. Min. Jour.*, **105**, 720 (1918).

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GRAPHITE

By Benjamin L. Miller

The graphite situation throughout 1918 was even more abnormal than during the preceding years of the war. The stimulus of the increased demand for graphite crucibles resulted in the development of additional properties and the industry was prosperous until the signing of the armistice in November, although the market for domestic flake declined several months before. Almost complete stagnation prevailed during the closing weeks of the year and it will probably be several years before the industry again becomes stable.

The unusual demand for graphite crucibles on the part of the brass and steel manufacturers during 1915, 1916, and 1917 resulted in high prices and ready sales of practically all kinds of flake graphite. The shortage of shipping, together with embargoes placed on the export of Ceylon flake by England and of Madagascar flake by France, still further increased the demand for the domestic product. Some of the graphite companies already in a producing stage benefitted by the increased demand and high prices and were very prosperous during the entire period of the war. Others, however, experienced so many difficulties with their labor, on account of their former workmen leaving for military service or to enter the more remunerative work of munitions manufacture, that they profited but little. The new companies that opened quarries and built mills on the strength of the boom in the industry were left in an unfortunate situation when the demand for crucible graphite decreased, in some cases as the companies were just starting production.

The many domestic flake-graphite producers have long maintained that their product was as well adapted to the manufacture of crucibles as the Ceylon flake that has been mainly employed by the crucible manufacturers, and that it was only conservativeness on the part of the latter that prevented them from substituting the domestic for the imported material. It was therefore hoped that the unusual war conditions would result in the larger use of the domestic flake and eventual complete replacement of the imported material. The hopes of the domestic pro-

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ducers have not been realized and the field for their product, although temporarily widened, bids fair to shrink to its former proportions. This means that the United States, at least, faces an overproduction which will eliminate the less favorably situated or less efficient companies.

Experiments carried on by the United States Bureau of Mines to determine the properties of domestic flake and the possibility of using larger proportions in the manufacture of crucibles have not been completed. Many of the experiments were not conclusive and further experimentation is required. Dr. Reinhardt Thiessen, who studied graphites microscopically, found "that the prevailing structure of most American graphites was of rather large and rather rounded grains; and that most of these had such a distinct lamination that the resulting mixture was sure to be laminated and to show the weakness of laminated cleaving. But the Ceylon graphite was shown to be made up, for the most part, of large and small grains, and with much irregularity of outline, but largely of angular shapes; and the cleavage was not of the always parallel lamination, but of much irregularity in dimension and direction, so that, when mixed in crucibles, the whole would develop a much more coherent mass than was possible with the average American graphite."

The general consensus of opinion among graphite crucible manufacturers seems to be that the best results can be obtained by using at least 80 per cent. of Ceylon flake, with the balance either Madagascar, Canadian, or American product. Consequently the graphite producers of these latter three countries must compete among themselves in the markets of the world, but they can not wholly or even largely supplant Ceylon graphite. Electric-furnace steel is also replacing crucible steel in large measure so that the crucible market for most of the graphite producers does not present attractive opportunities. For these reasons it is unfortunate that the boom in the industry resulted in the development of so many new properties, many of which will doubtless be compelled to liquidate. On the whole, the war and its effects on the graphite industry have been decidedly disastrous and recovery will come about slowly.

The most beneficial results in the United States were along new lines of graphite concentration inaugurated in the new mills.

Graphite Production in the United States

The quantity of domestic crystalline graphite marketed in 1918, as shown by the final figures compiled by the United States Geological Survey, is indicated in the table following.

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CRYSTALLINE GRAPHITE SOLD IN THE UNITED STATES IN 1918

State.	Pounds.	Value.
Alabama	7,795,475	$999,152
New York	3,266,518	273,188
Pennsylvania	1,016,900	112,059
California, Montana, Texas	782,946	70,400
	12,861,839	1,454,799
Sales in 1917	10,584,080	1,094,398

Amorphous graphite to the amount of 6560 short tons, valued at $69,455, was sold from mines in Colorado, Nevada, and Rhode Island. The output of amorphous graphite in 1917 was 8301 short tons, valued at $73,481.

STATISTICS OF GRAPHITE IN THE UNITED STATES

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports.		Consumption. (a)			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Short Tons.	Value.
1903	4,525,700	$164,247	32,012,000	$1,207,700	36,537,700	$1,371,947	16,591	$ 71,384
1904	4,357,927	162,332	25,350,000	905,581	29,707,927	1,067,913	19,115	102,925
1905	4,260,656	170,426	34,914,611	983,034	39,175,267	1,153,460	21,953	80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	16,853	(b)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	54,829,771	1,897,026	2,063	32,894
1913	5,064,727	254,328	57,758,400	2,109,791	62,823,127	2,364,119	2,243	39,482
1914	5,220,539	285,368	44,004,800	1,398,261	49,225,339	1,683,629	1,725	38,750
1915	7,074,370	417,273	46,155,200	2,241,163	53,229,570	2,658,436	1,181	12,358
1916	10,931,989	914,748	86,033,920	7,279,884	96,965,920	8,194,632	2,622	20,723
1917	10,584,080	1,094,398	85,218,000	8,961,988	95,802,080	10,074,236	8,301	73,481
1918	12,861,839	1,454,799	38,996,160	3,092,475	51,857,999	4,547,274	6,560	69,455

(a) Neglecting the small re-export of foreign product. (b) Not reported.

The outstanding feature of the year was the advance made in the milling of graphite ore. Some of the old methods still exist, although they are subordinate to newer processes that have been proved successful. A list of the processes now in use or recently employed in the United States follows:

Water Processes: Log washers, buddles, tables, float boxes, oscillators.
Oil Processes: Minerals Separation, Callow, Simplex, K. & K.
Dry Processes: Pneumatic, screening, Sutton, Steele & Steele.
Electrostatic Process: Huff.

There are many different modifications of several of these processes, especially the float-box process, and also various combinations of the processes. These are described in a forthcoming report on "The Graphite Industry of Pennsylvania" by the writer, and also by Dub and Moses

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in two brief reports in the War Minerals Investigations Series of the Bureau of Mines. Each process has its defenders, which indicates that the personal element enters largely into the choice of the mill equipment, although it is now recognized that no one process is equally adapted to all types of ore. Even in any particular district, with similar ores, it is doubtful whether any one standard concentration process is apt to be selected.

The embargoes placed on imports of foreign graphite by the War Trade Board were also important features of the graphite industry of the United States during 1918. On April 15 a ruling was issued to the effect that no foreign graphite should be imported before July 1, and after that date no more than 5000 tons during the remainder of the year. On July 2, the Board ruled that no foreign graphite should be imported during the following 6 months, but on Oct. 2 issued a modification as follows:

"No licenses for the importation of amorphous graphite (plumbago) shall be issued hereafter, except such shipments as are of Canadian origin and come overland or by lake from Canada, or of Mexican origin and come overland from Mexico.

"Licenses may be issued for the importation of graphite of crucible grade, when the applications therefor are otherwise in order, and where the Chemical Section of the War Industries Board has approved the issuance of said license, and has certified that the ultimate consumers of the said graphite have been using at least 20 per cent. of domestic or Canadian flake graphite in the manufacture of their products."

On July 2 the importation of graphite crucibles after July 15 was also forbidden.

The result of these various embargoes assured the graphite producers of a market for part of their product in that at least 20 per cent. of domestic flake had to be used by the crucible manufacturers. There was considerable discussion in regard to price fixing by the Government, but no action was taken.

In spite of the urgent request on the part of the producers that the embargoes be continued during the coming year, this was not done, and all embargoes were removed in January, 1919.

The prices for American flake were somewhat lower than in 1917. No. 1 domestic flake of 85 to 90 per cent. carbon averaged 16 to 17 cts. per lb. f.o.b. mines, although sales were made for less. Considerable amounts remained unsold. The producers maintained that they should receive as high prices as during 1917, when the costs of producing were much less. During a part of the year there was so little demand for flake of lower grade that some producers unable to make an 85-per cent. carbon grade had difficulty in disposing of any of their product.

Alabama.—During 1918 Alabama retained its foremost position

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and produced 60 per cent. of the domestic flake sold. It yielded almost $1,000,000, somewhat more than one-fourth of the estimated investment in the entire graphite district.

The following paragraphs are taken from a short article[1] by Dr. W. F. Prouty written early in 1919:

There was a steady growth in the Alabama graphite industry in 1918, despite the serious freight-car shortage in the latter period of 1917 and during the early part of 1918, and despite, also, the serious handicap produced by the labor shortage and the difficulty of getting repair parts and new machinery. Fourteen plants reported sales in 1917. Thirty plants were in operation in December, 1918, 24 of which were working in Clay County, 5 in Coosa County, and 1 in Chilton County.

During 1918, two mills, that of the Empire Graphite Co. and that of the Eagle Graphite Co., were completely destroyed by fire, which also destroyed the concentrating plant belonging to the Griesemer Graphite Co. Two of these plants are now being rebuilt, and the third company is making preparations to rebuild.

Two or three new graphite companies are planning to construct mills in the near future, but the great rush for new plants is over, and the business is now settling down to determine ways and means of increasing the percentage of recovery, reducing the cost of production, raising the grade, and standardizing the product. Consolidation of some of the companies has already taken place, notably that resulting in the forming of the Quenelda Graphite Corporation. Other companies are considering consolidation, for the gain from such action secures not only economy of management and reduced cost of production, but, perhaps, what is more important, a better standardization of the product. The percentage of No. 1 flake is increased by the mixing of larger and finer flake from the different mills, and this is of especial advantage in the mixing of products from the wet and the dry processes.

The cost of production of graphite has risen greatly since 1913. After careful consideration of the cost of production, and allowing for a reasonable profit only, the Graphite Producers' Association of Alabama suggested the following prices as being just at this time, both to the producer and to the manufacturer. To this suggestion the Government consented, although there has been no price fixing.

SCHEDULE OF PRICES ADOPTED BY THE GRAPHITE PRODUCERS' ASSOCIATION OF ALABAMA

Grade.	Per Cent. Carbon.	Price per Pound.
No. 1 Flake	90	20½ cts.
No. 1 Flake	85	15½ cts.(*a*)
No. 2 Flake	80	10 cts.(*b*)

Per Cent. Carbon.	Price per Pound.	Per Cent. Carbon.	Price per Pound.
25 to 30	1 ct.	60 to 65	4½ cts.
30 to 35	1¼ cts.	65 to 70	5½ cts.
35 to 40	1½ cts.	70 to 75	6½ cts.
40 to 45	2 cts.	75 to 80	7½ cts.
45 to 50	3 cts.	80 to 85	10 cts.
50 to 55	3½ cts.	85 to 90	12 cts.
55 to 60	4 cts.		

(*a*) With 1 ct. added for each per cent. above the 85 per cent. carbon.
(*b*) With ½ ct. added for each per cent. above the 80 per cent. carbon.
TERMS: F.o.b. Ashland, Alabama, or nearest shipping point; 75 per cent. of invoice payable upon receipt of bill of lading; balance upon receipt and satisfactory examination of material.

[1] *Eng. Min. Jour.*, **107**, 194 (1919).

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New York.[1]—The Adirondack graphite industry exhibited some progress during 1918, but the district can hardly be compared in that respect with Alabama. The latter experienced a remarkable development under the stimulus of war conditions, and now has outdistanced the older field as a mining center. Operations were maintained throughout 1918 at three New York graphite mines, all of which were active in 1917. These included the American mine at Graphite (one of the holdings of the Joseph Dixon Crucible Co.), the Hooper Brothers' mine at Whitehall, and the mine of the Graphite Products Corporation at Saratoga Springs. Some work was performed by the Flake Graphite Co., the only other enterprise that was equipped for operation, with a mine and mill situated in the town of Greenfield, west of Saratoga Springs. No new projects were under development that may be expected to start production within the current season, although some interest has been shown in a number of other properties, including the Faxon, which adjoins the American mine; the Bly property, west of Ticonderoga; and the Smith prospect, which lies in the extreme northern part of Essex County.

With an estimated production of about 5,000,000 lb. of concentrates, the actual output was somewhat below that figure. Each of the operative companies carried out improvements and enlargements of installation that interfered with the normal running of the plants. Market conditions were practically on the same basis as in 1917, and a steady demand for the output and good prices obtained under the influence of the restrictions put upon importations. It would be difficult to give average figures of sales, as they varied for each mine according to size and purity of the products, in which respect there was some variation also between one shipment and another from the same mine. The mill concentrates comprised three grades: No. 1 flake, with 86–90 per cent. carbon; No. 2 flake, of finer size and with about 80 per cent. carbon; and dust containing 40–45 per cent. carbon. The last grade is practically a waste product for mines not equipped to put products in final finished forms.

A bulletin prepared by Harold L. Alling, and just issued by the State Geologist's office, gives a full account of the Adirondack deposits, with information as to the nature and tenor of the ores and other details of interest from the operating standpoint. It is not entirely apparent why the region should not have shared more fully in the recent expansion of the American industry, although the Alabama ores, no doubt, are easier to mine and to crush. On the other hand, the Adirondack rock carries 1 or 2 per cent. more graphite on the average and produces a cleaner, brighter flake. The general average of the mined rock is about 5 per cent., as compared with 3 per cent. estimated for the Alabama ores.

[1] D. H. Newland, *Eng. Min. Jour.*, **107**, 148 (1919).

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Pennsylvania.—During 1918 the mill of the Rock Crucible Graphite Co., with the Huff Electrostatic equipment, was completed and began operation. Considerable difficulty was encountered both in the quarry and in the mill, so that the plant was only just prepared for continuous operation when the armistice was signed. The Tonkin Graphite Co. passed into the hands of the E. C. Hargraves, who replaced the K. & K. oil flotation machine with a water flotation process. H. A. Schmehl relinquished his lease on the property of the Philadelphia Graphite Co. and moved to Pikeland, where he carried on experiments in the recovery of graphite from old graphite crucibles. The Standard Carbon Co. operated during only a part of the year. The only companies in practically continuous operation were the Graphite Products Co. at Byers and the T. D. Just Co. near Chester Springs, and these were compelled to close at times on account of the unusually cold weather during January and February, the difficulty experienced in obtaining coal, and the labor shortage.

Texas.—Dub visited the Texas district during the summer of 1918 and prepared a description[1] from which the following is abstracted:

In Texas graphite is found in the silicious pre-Cambrian Packsaddle schist occurring in the central region of the State between the towns of Llano and Burnet. This schist is a metamorphosed sedimentary in which the carbonaceous materials have recrystallized to form graphite. The ore analyzes 6 to 10 per cent. graphitic carbon, but the recovery of No. 1 flake is comparatively low because of the presence of amorphous graphite and very small flake in the ore; moreover, the gangue is hard, so that in crushing, a large amount of the flake is destroyed by being ground to finer sizes than are used as No. 1 flake.

Three properties are now operating in the State. The Southwestern Graphite Co., 9 miles west of Burnet, and the Burnet-Texas Graphite Co., 7 miles west of Burnet, have developed open pits; the Dixie Graphite Co., 4 miles northeast of Llano, is mining underground. In concentrating two plants use the oil-froth flotation methods and the third the Huff electrostatic machines. No refining plants are as yet in operation.

The Texas district is fortunate in being able to obtain a fair supply of native white labor, which has not been drawn from the district by the attraction of high wages paid in various manufacturing centers.

Other States.—California produced graphite from the deposit in Los Angeles County and the Dillon, Mont., project was also in operation. The graphite from the latter district is of high grade, but considerable difficulty in mining and transportation has been experienced, so that only about 100 tons was shipped during the year.

[1] War Min. Invest. Series, No. 3, 15–17 (1918), U. S. Bureau of Mines.

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Amorphous graphite, used largely for foundry facings, was mined extensively in Rhode Island, Colorado, and Nevada, as in former years.

Graphite in Foreign Countries

Canada.—The production of graphite in Canada during 1918 was somewhat less than during the preceding year. Ontario furnished almost the entire production, although 117 tons valued at $24,504 was produced in Quebec (including a small shipment from Baffin Land), according to the preliminary statement of the Canadian Department of Mines.

Ontario.[1]—The production of refined graphite in Ontario for 1918 was 3022 tons, as against 3173 tons in 1917, valued at $210,018. Three companies were in operation: the Black Donald Graphite Co., at Calabogie, on the Kingston and Pembroke; the Globe Graphite Mining and Refining Co., at Port Elmsley, on the Rideau Canal, and the Timmins Graphite Co., which was engaged in building a mill and developing a new property on Lot 24 in the fifth concession of North Burgess Township.

The Black Donald mine is an important deposit situated on the shores of Whitefish Lake, and employed about 130 men. The refined products average about 25 per cent. flake and 75 per cent. intermediate and low grades known as foundry plumbago. At the Globe mine and mill 14 men were employed. The management carried on considerable experimenting with concentration methods during the year, and modified the processes in use so as to obtain a considerably larger recovery. The product is divided into large flake, small flake, and dust. On the property of the Timmins Graphite Co. a vein which varies in width from 25 to 27 ft. has been traced for about a mile and stripped for a short distance. The company has purchased 300 acres of land, and the mineral rights on 400 acres additional. The mill, which is 42 by 72 ft., with a capacity of 200 tons per day, is nearly completed, and the machinery is ready to be installed and is expected to be in operation by Feb. 1, 1919.

Prices for flake graphite averaged from $140 to $320 per short ton, and plumbago sold for from $45 to $80. The demand for flake was dull throughout 1918. There was a fairly satisfactory call for plumbago until November, when business became flat, and it continued so until the end of the year.

Ceylon.—U. S. Consul Walter A. Leonard summarizes the Ceylon graphite industry of 1918 in the following paragraphs:

> The decreased shipments of graphite to the United States during 1918 adversely affected the Ceylon plumbago industry. In 1916 the United States took 75 per cent. of Ceylon's plumbago and in 1917 over 81 per cent., while in 1918 America took barely 55 per cent. (percentage based on quantity, not value). Even before the total

[1] Thomas W. Gibson, *Eng. Min. Jour.*, 107, 196 (1919).

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prohibition of import was put into effect on July 1, 1918, the American shipments had been considerably below normal.

Exports of Ceylon plumbago in 1918 were considerably less than in any previous year during the past 10-year period, except in 1914, when 14,300 long tons was exported, as compared with 15,500 tons in 1918. In the record year of 1916 exports totaled over 33,000 tons, compared with approximately 27,000 tons in 1917. The years 1909, 1910, 1912, and 1913 showed exports greater than those in 1917 and nearly equal to the figures of 1916, although the value of the exports during these earlier years was less.

The distribution of plumbago exports covering the years 1917 and 1918, respectively, as compiled by the Ceylon Chamber of Commerce, is given in the following table:

Countries.	1917.	1918.	Countries.	1917.	1918.
	Long Tons.	Long Tons.		Long Tons.	Long Tons.
America	21,965	8,409	Japan	.....	61
United Kingdom	4600	6,386	Russia	100	.....
India	145	303			
Australia	237	294	Total	27,047	15,453

It is reported locally that the high prices of Ceylon plumbago in 1916 and early 1917 enabled competition from Madagascar and other graphite fields to react against the Ceylon market. It is not anticipated that such high prices will rule again in Ceylon. The lump plumbago is now quoted at $115 to $225 per long ton as compared with prices ranging as high as $500 in late 1916 and early 1917. Prices of other grades of plumbago are at present comparatively low, chips ranging from $65 to $150, dust from $20 to $100, and flying dust as low as $13 per ton.

Chosen (Korea).—There was little activity in the graphite industry of Chosen during 1918, mainly on account of the difficulties of ocean transportation.

Madagascar.—The graphite industry of Madagascar suffered during 1918 on account of lack of ships to take the material to England and France, and also on account of the restriction of imports into the United States. Large quantities accumulated in Marseille and still larger amounts remained in the country. By the middle of the year the greater portion of the mines had been closed and others ceased operations after the signing of the armistice.

The country occupies the most favorable position of all countries in the production of flake graphite. It is said that Madagascar can readily furnish from 35,000 to 40,000 tons of flake of 85+ per cent. carbon annually, at a cost of less than 5 cts. per lb. at the mines, and that the country will yield about 2,000,000 tons of graphite by open-cut workings and over 5,000,000 tons if worked to a depth of 60 meters (185 feet). It therefore appears that this island will long be a most important factor in the world's graphite markets.

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During 1918 Madagascar flake sold in New York at 13 to 15 cts. per lb. until the signing of the armistice, when it dropped to 10 cts. A further drop to about 8 cts. was predicted for 1919.

Mexico.—Some new mines of amorphous graphite, similar to that long produced by the United States Graphite Co., were opened during 1918 and made small shipments.

Norway.—According to *Norges Utenrikshandel* a deposit of graphite in Skaland, in the district of Senjen in Nordland, Norway, contains a sufficient quantity to supply the Norwegian market for a number of years. Tests seem to have been very successful, indicating that it is possible to produce graphite of any desired quality. A plant for working the deposits is planned.[1]

Siberia.—During the year 1918 some high-grade graphite ore, said to contain 90 to 97 per cent. carbon, was mined in the vicinity of the famous old Alibert mines.

South Africa.—Graphite has long been known to occur in several places in South Africa. These localities were described in the *South African Journal of Industries* for February, 1918. At the present time the output is very small and there is no immediate prospect of any big increase. Nevertheless, owing to shipping restrictions a large part of the South African demand is being met locally, so that the industry stands a fair chance of development.

Spain.[2]—In the Province of Malaga there are important deposits of graphite which occur in crystalline rocks. One analysis gave 24 per cent. C; 32 Si; 4 Ni; 3 per cent. Co; the presence of nickel and cobalt is not the rule. The mines of Marbella are the best known. In the eighteenth century they produced 8000 tons. In the Province of Barcelona a small amount of graphite is won from Silurian slates. In the Province of Huelva the graphite is found in the crystalline formation, the rock being gneiss. It appears that the mica has been replaced by graphite. One observes abundant mica in the country rock, but very little in the graphite formation. The latter occurs in a narrow belt about half a mile wide by 10 miles in length, with two rich patches in between, both of which are now being exploited. The mineral is found in a sheared mass from stringers up to 10 m. in width. The average from samples taken gave 10 per cent. carbon. The deposits dip nearly vertically and strike east and west. At two of these mines concentration plants are being erected, and much interest will be taken in this new industry. Concentration trials have been made on a small scale, obtaining a finished product of 85 per cent. carbon. No doubt higher concentration will be

[1] *Comm. Rept.*, Apr. 24, 1918.
[2] E. M. Harriot, *Min. Mag.*, **19**, 133 (1918).

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possible. The mineral will be crushed to under 30 mesh by Cornish rolls and Chilean mills. The concentration will be carried out on buddles 6 m. in diameter, and the concentrates refined by specially constructed machinery. The finished product is a flake graphite.

WORLD'S PRODUCTION OF GRAPHITE
(In metric tons)

Year.	Austria.	Bavaria.	Canada.	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	France and Colonies.
1903	29,590	3,719	660	24,492	3,448	7,920	114	1,404	25	2,053	.....
1904	28,620	3,784	410	26,478	2,955	9,765	216	970	55	2,045	.....
1905	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	.....
1906	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	.....
1907	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	.....
1908	44,425	4,844	227	26,227	2,919	12,914	177	1,076	66	1,557	300
1909	40,710	(e)4,900	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910	33,131	7,415	1,263	30,008	4,319	12,510	145	2,332	49	3,811	1,100
1911	41,599	11,298	1,154	27,433	4,047	12,621	114	2,974	65	3,280	1,870
1912	45,375	12,532	1,873	33,106	*Nil.*	13,170	149	2,865	79	3,318	5,600
1913	49,456	12,032	1,961	29,277	*Nil.*	11,145	665	1,057	88	4,331	(e)7,000
1914	.....	.....	1,494	14,451	*Nil.*	8,567	574	3,864	56	3,935	.....
1915	.....	.....	2,368	22,159	71	6,176	666	1,524	87	4,280	.....
1916	.....	.....	3,589	33,947	1,341	8,182	1,144	4,836	194	7,339	.....
1917	.....	.....	3,866	27,482	105	12,117	1,329	6,868	123	12,331	.....
1918	.....	.....	2,768	15,702	.....	.....	.....	.....	.....	11,785	.....

(a) The figures for 1907, 1908, and 1912 to 1918 are exports. (b) Exports. (c) Crystalline graphite up to 1909. Does not include artificial graphite. (e) Estimated.

Manufactured or Artificial Graphite

The International Acheson Graphite Co. continue to produce large quantities of graphite, the bulk of which is used for electrical purposes.

Production of Manufactured Graphite, 1899–1918

Year.	Quantity, Lb.	Value.	Price per Pound, Cents.
1899	405,870	$32,475	8.00
1900	860,750	68,860	8.00
1901	2,500,000	119,000	4.76
1902	2,358,828	110,700	4.69
1903	2,620,000	178,670	6.82
1904	3,248,000	217,000	6.70
1905	4,595,500	313,979	6.83
1906	4,868,000	312,764	6.42
1907	6,924,000	483,717	6.97
1908	7,385,511	502,667	6.80
1909	6,870,529	467,196	6.80
1910	13,149,000	945,000	7.19
1911	10,144,000	664,000	6.54
1912	12,896,347	830,193	6.44
1913	13,633,342	973,397	7.14
1914	10,455,139	698,800	6.68
1915	(a)5,580,437	109,102	1.96
1916	(a)8,922,329	.....	....
1917	(a)10,474,649	.....	....
1918	(a) 9,182,272	.....	....

(a) Powdered graphite only; electrode material not included.

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GYPSUM

By Frank A. Wilder

Building activities during 1918 pursued an erratic course, governed almost entirely by factors having to do with the war. The course of the gypsum industry for the year is accurately plotted by the same curve that is used for plotting construction work.

The Government discouraged all forms of private building enterprises that did not have a direct bearing on winning the war, during the earlier months of 1918, and this policy reached a climax in the fall when gypsum producers were asked to pledge themselves not to sell their products for any enterprise that came within the scope of the Government's interpretation of "non-essential." At the same time, to compensate partly, the Government's requirements of gypsum products for housing and roofing purposes steadily increased, until the volume of Government orders, for mills in the eastern district, at the time the armistice was signed gave substantial relief for the loss of normal business.

The demand for plaster board and gypsum wall-board was tremendously stimulated during the last four months of the war by Government housing operations. The excellent showing made by gypsum boards, as a substantial and a fire-retarding construction material, resulted in a federal order which took over for Government use the entire output of all the gypsum-board plants in the country.

The cutting off of Nova Scotia gypsum for the making of finishing plasters brought to the front the merits for this purpose of certain beds of domestic mineral. The excellent quality of some of our American finishing plasters is, in consequence, receiving proper though long-deferred recognition.

CRUDE GYPSUM MINED IN THE UNITED STATES (a)
(Tons of 2000 lb.)

1883	90,000	1895	265,503	1907	1,751,748
1884	90,000	1896	224,254	1908	1,721,829
1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1902	816,478	1914	2,476,465
1891	208,126	1903	1,041,704	1915	2,447,611
1892	256,259	1904	940,917	1916	2,756,630
1893	253,615	1905	1,043,202	1917	2,696,226
1894	239,312	1906	1,540,585	1918	2,056,462

(a) Statistics of the U. S. Geol. Surv.

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Plaster of Paris from American mills proved wholly satisfactory to army officials in orthopedic surgery, and many carloads were used for this purpose. Open-mesh bandages were run through a receptacle containing the dry plaster till the meshes were filled. The bandages were then rolled and packed for later use. Before using, the rolls were soaked in water for a minute or two, then unrolled and wrapped quickly about the injured part. The prompt setting of the Plaster of Paris produced a tough strong splint.

Millions of buttons used on military uniforms had as their base raw gypsum, which was mixed with shellac, rosin, and coloring matter and moulded hot in an automatic press.

During 1918 there were 70 producers of gypsum products in the United States. Of this number there were 32 manufacturers of calcined plaster, who operated 56 calcining plants.

New York State again led in gypsum output and its lead over Iowa, which was second in both 1917 and 1918, was increased on account of New York's favorable position with reference to the Government's needs. The Iowa tonnage was further restricted by the burning of the Wasem mill, at Fort Dodge.

CRUDE GYPSUM MINED IN THE UNITED STATES, 1917–1918 (a)

State.	1917. Quantity Mined (Short Tons).	1918. Quantity Mined (Short Tons).
California	30,552	(b)
Iowa	461,864	327,927
Kansas	79,331	54,958
Michigan	375,803	286,768
New York	606,268	531,038
Ohio	270,538	199,456
Oklahoma	158,017	126,208
Texas	257,328	157,388
Wyoming	55,844	41,877
Other States (c)	400,681	330,842
Total	2,696,226	2,056,462

(a) R. W. Stone, U. S. Geol. Surv.
(b) Included with "Other States."
(c) Includes, 1917: Alaska, Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Virginia; 1918: Arizona, California, Colorado, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Virginia.

Crude gypsum mined in the United States decreased 639,764 tons, or 24 per cent., as compared with 1917. A considerable part of this decrease came during the last 2 months of the war, after the signing of the armistice. All Government orders were promptly canceled with the cessation of military activities, and other construction work had

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GYPSUM PRODUCED AND MARKETED IN THE UNITED STATES, 1913–1917[1]

Year.	Sold Without Calcining.											
	For Portland Cement.			As Land Plaster.			For Other Purposes.			Total.		
	Quantity, Short Tons.	Value	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.
1913	(a)408,221	(a)$600,913	$1.47	54,815	$95,953	$1.75	100	$200	$2.00	463,136	$697,066	$1.51
1914	(a)390,742	(a) 549,083	1.41	52,945	97,716	1.85	.....	.....	.....	443,687	646,799	1.46
1915	(a)406,393	(a) 528,161	1.30	69,256	122,714	1.77	.....	.....	.....	475,649	650,875	1.37
1916	(a)454,112	(a) 607,995	1.34	81,879	167,136	2.04	11,128	15,299	1.37	547,119	790,430	1.44
1917	(a)526,881	(a) 867,123	1.65	84,366	230,808	2.74	12,748	26,439	2.07	623,995	1,124,370	1.80

Year.	Sold Calcined.														
	As Plaster of Paris, Wall Plaster, Keene's Cement, etc.			For Dental Plaster.			To Glass Factories.			As Boards, Tile, and Blocks, and for Other Purposes.			Total.		
	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.
1913	1,680,157	$5,858,785	$3.49	861	$4,168	$4.84	10,942	$21,797	$1.99	81,889	$193,006	$2.36	1,773,849	$6,077,756	$3.43
1914	1,565,937	6,038,777	3.86	641	3,374	5.26	(b)	(b)	.....	(b)89,488	207,039	2.31	1,656,066	6,249,190	3.77
1915	1,520,308	5,776,826	3.80	534	2,376	4.45	11,861	26,620	2.25	81,017	140,196	1.73	1,613,720	5,946,018	3.68
1916	1,677,081	6,884,960	4.11	661	8,766	13.26	11,537	28,839	2.50	116,535	246,037	2.11	1,805,814	7,168,602	3.97
1917	1,531,535	8,873,176	5.79	991	7,672	7.74	13,808	72,558	5.25	142,528	417,567	2.93	1,688,862	9,370,973	5.55

[1] Gypsum in 1917. R. W. Stone, U. S. Geol. Surv.
(a) A small quantity of paint material included with gypsum sold for Portland cement.
(b) Some calcined gypsum sold to glass factories included under "As boards, tile, etc."

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been so effectively discouraged that there was very little demand for plaster.

The decrease in production was least in New York, where the output fell off only 12 per cent., while in Oklahoma, Michigan, and Ohio, the decrease was 20 to 26 per cent., or about the average for the country. Texas suffered the greatest reduction in output, about 39 per cent. Utah was the only State which produced more gypsum in 1918 than in 1917.

The value of gypsum and gypsum products produced in the United States in 1918 was $11,470,004, which may be compared with $11,116,452 in 1917.

Production costs increased correspondingly during the year. From 1914 to 1918 the increase in cost of production of gypsum plasters was 81 per cent., whereas the increase in the selling price was only 77 per cent.[1]

The recently discovered gypsum deposit at Centerville, Iowa,[2] was developed during 1918 by the erection of a mill at Centerville. The gypsum lies in the Mississippian beds, below the coal measures, and is reached by a 500-ft. shaft. The mill installed at Centerville was moved to that point from Alva, Okla.

A fire in the shaft of the gypsum mine on Chichagof Island, Alaska, in March, cut off Alaska from the list of producing points for the remainder of the year, and the mill at Tacoma, Wash., secured its mineral from Oregon.

The Globe Plaster Co., with mill at Globe, N. M., and office at Kansas City, Mo., extended its operation and improved its transportation facilities during the year.

The Wheatland Consolidated Plaster Co. plant at Wheatland, central New York, was sold in foreclosure proceedings in August, 1918, to the Ebsary Co., makers of gypsum blocks.

The Arden Plaster Co., which for several years maintained a plant at Arden, Nev., moved its plant to Los Angeles, and transports raw material 350 miles to that city.

New York (By D. H. Newland).—The gypsum industry, like the other mineral industries tributary to the building trades, experienced a considerable decline in business last year. The decrease of production, on the basis of the crude rock, was approximately 75,000 short tons, or a little over 12 per cent. of the total of 606,268 short tons which represented the amount of crude rock mined or quarried in 1917. The statistics of the industry for the past 3 years are here given:

[1] Figures presented to the Industrial Board of Department of Commerce by O. M. Knode, Chairman of War Service Committee of Gypsum Industries Association.
[2] MINERAL INDUSTRY, 23, 384 (1914).

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PRODUCTION OF GYPSUM IN NEW YORK[1]

Material.	1916.		1917.		1918.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
Total output, crude	579,827	.....	606,268	.....	531,038	.....
Sold crude	188,087	$273,322	218,094	$400,836	179,968	$442,087
Ground for land plaster	7,169	18,700	5,298	20,235	3,139	14,552
Wall plaster, etc., made	311,264	1,167,555	304,364	1,615,749	275,333	2,213,460
Total	.....	$1,459,587	.....	$2,036,820	.....	$2,670,099

[1] U. S. Geol. Surv. and N. Y. State Geol. Surv.

The falling-off may be considered as having little or no significance with respect to the general trend of the business under normal conditions, since it was the result of the Governmental policy in reducing non-essential activities enforced during most of the year. As a result very little gypsum was marketed except for the necessary ends of industry. With the resumption of building activities there is likely to be a large expansion in the output of calcined gypsum and gypsum plasters, as the market for these materials is still capable of large growth.

No new mines were opened in 1918. The output of gypsum for calcining came from the Garbutt, Oakfield and Akron districts in the western part of the State; a small quantity of agricultural rock was obtained in the eastern sections of Madison and Onondaga counties. It is not unlikely that one or two new enterprises will begin operations soon in the western area, where prospecting for deposits has been actively carried on in the last year or two.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES (a)
(In metric tons)

Year.	Algeria. (b)	Canada. (g)	France. (b)	Germany. (c)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1901	44,025	266,476	2,385,633	28,183	3,581	671	(d)	204,045	598,529
1902	44,975	301,165	2,185,346	33,150	31,701	*Nil.*	(d)	228,264	740,906
1903	41,550	285,242	1,998,804	29,423	30,894	94	(d)	223,426	945,285
1904	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,626
1906	27,950	378,904	1,377,429	25,643	50,763	70	(e) 5,000	228,627	1,397,480
1907	26,400	431,286	1,316,567	29,153	48,975	70	(e) 5,000	239,285	1,564,061
1908	25,500	346,436	1,750,562	35,217	51,314	*Nil.*	(e) 5,000	231,980	1,694,155
1909	36,250	398,290	1,655,672	36,621	51,630	191	17,588	242,832	(f) 2,042,286
1910	60,625	481,941	1,980,804	41,078	54,397	249	13,759	259,648	(f) 2,158,756
1911	61,502	470,381	2,110,520	42,408	60,390	1,263	11,115	281,111	(f) 2,112,770
1912	54,414	524,892	2,150,900	51,777	57,114	127	21,383	247,724	(f) 2,269,290
1913	50,413	577,442	1,726,379	49,767	.....	2,245	25,362	242,341	(f) 2,357,752
1914	.....	463,375	.....	.....	.....	639	22,639	269,637	(f) 2,247,246
1915	.....	430,752	.....	.....	.....	1,648	22,926	251,209	(f) 2,220,458
1916	.....	311,092	.....	.....	.....	356	16,826	222,814	(f) 2,500,815
1917	.....	305,120	.....	.....	.....	.....	16,952	175,800	(f) 2,446,016
1918	.....	138,155	.....	.....	.....	.....	.....	.....	(f) 1,865,622

(a) From official reports of the respective countries, except the statistics for the United States. (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum, but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistics not available. (e) Estimated. (f) U. S. Geol. Surv. (g) Tonnage shipped. See detailed statement on Canada for total tonnage produced.

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Canada.[1]—Because of the great cessation of building activities during the war the production of gypsum has fallen in 1918 to less than one-quarter of the tonnage mined in 1913. The difficulties in securing boat transportation for shipments from the Maritime Provinces was a contributary cause of decreased output. The total quantity of gypsum rock quarried in 1918 was 155,298 tons, of which 88,748 tons was calcined. The shipments of all grades totaled 152,287 tons, valued at $823,006, and included lump gypsum, 43,728 tons valued at $47,727; crushed, 25,074 tons valued at $55,079; fine ground, 4558 tons valued at $12,621; and calcined, 78,927 tons valued at $707,579. By provinces the shipments were: Nova Scotia, 49,365 tons valued at $115,976; New Brunswick, 27,225 tons valued at $214,114; Ontario, 38,214 tons valued at $151,564; Manitoba, 37,483 tons valued at $341,352.

In 1917 the quantity quarried was 365,659 tons, of which 97,667 tons was calcined. The shipments included: lump, 223,760 tons valued at $246,774; crushed, 32,305 tons valued at $51,869; fine ground, 4843 tons valued at $19,222; and calcined, 75,424 tons valued at $564,119; or a total of 336,332 tons valued at $881,984.

The average number of men employed in 1918 was 435 and wages paid were $273,728, as compared with 774 men employed and $445,128 paid in wages in 1917.

Exports of crude gypsum were 67,824 tons valued at $80,843, and in addition ground gypsum valued at $101,618. The corresponding exports in 1917 were: crude gypsum, 224,423 tons valued at $245,182, and ground gypsum to the value of $146,384. The imports of gypsum of all grades during 1918 were valued at $22,065 and included: crude gypsum, 112 tons valued at $2015; ground gypsum, 79 tons valued at $1836; and Plaster of Paris, 1096 tons valued at $18,214. The total value of the imports in 1917 was $35,460.

England, Nottingham District.[2]—Gypsum is found in the Keuper marls on the Midland Counties in large quantities, as well as more sparingly elsewhere in the United Kingdom. The total production for the year 1913 was 285,338 long tons. Of this quantity more than one-half was obtained from the Nottingham district. In Nottinghamshire it is found in large quantities at Newark, Bowbridge, Cropwell Bishop, East Bridgford, Hawton, Gotham, and elsewhere. From an historical point of view the most famous gypsum mine is just over the border at Chellaston in Derbyshire, where the finer kinds of alabaster were obtained during the Middle Ages for the production of monumental effigies and other works of a similar nature. Nottingham was the chief exporting center of this branch of the alabaster industry.

[1] Prelim. Rept. Min. Prod. Can., Dept. of Mines, 1918.
[2] Consul C. M. Hitch, *Comm. Rept.*, May 8, 1919.

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Gypsum of the finest-superfine white grade is mined in the Nottingham district. It is specially selected for the manufacture of various products, and on account of its high quality meets with a ready demand from all parts of the world. The principal products of superfine gypsum are known as Mineral White or Terra Alba, Plaster of Paris, and Keene's cement.

Mineral White or Terra Alba is finely ground and silk dressed. It is used in the chemical industries and also as a base for paints and as a filler for cotton and other goods. It is of a pure white color and is packed for export either in single or double bags of 112 lb. or 224 lb. each, net weight, or in casks containing 280 lb. each. The normal price f.o.b. Hull or Liverpool is about 50s. ($12.15) per ton, packages extra.

The white superfine gypsum also produces the very finest grade of Plaster of Paris for dental work, and also for special ornamental and modeling work. Plaster of Paris is normally about 75s. ($18.22) per ton f.o.b. Hull or Liverpool, with an extra charge for packing. Experience has shown that the safest and surest method for shipping Plaster of Paris is in casks rather than in bags.

Keene's cement is manufactured from selected gypsum, and is exported for use in statuary work, special modeling, and also for the manufacture of artificial marble. In order to preserve the white color of the finished Keene's cement, the process of manufacture is quite expensive. The price of Keene's cement before the war f.o.b. Hull or Liverpool was about £5 10s. ($26.75) per ton, packed in casks with an extra charge for packing.

The gypsum products of the Nottingham district are principally exported to Australia, New Zealand, India, Canada, South Africa, South America, Portugal, Holland, Norway, Russia, and the United States.

Spain.—According to a description of the potash deposits of Spain given in the *Mining Journal* of Dec. 15, 1917, the salt formations near Suria, Spain are accompanied by heavy beds of gypsum and anhydrite.

Africa.[1]—The cement factories of the Union of South Africa have a constant need of gypsum, and a good deal of work has been done searching for the mineral. Up to the present the only deposits found have been irregular segregations in the soil of some valleys and pans in the more arid districts of Natal and the Orange Free State. The output from these is about 100 tons per month, valued at £300, and is hardly sufficient to meet the demand. The Orange Free State deposit is not being worked at present.

[1] *So. Afr. Min. Jour.*, Aug. 10, 1918.

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Gypsum in Agriculture

The figures given above show a 60-per cent. increase from 1913–1918 in the amount of gypsum sold for agricultural purposes, as land plaster. Although the tonnage is still small as compared with the total amount of gypsum mined, it is believed that the rate of increase will be maintained or exceeded. Indeed it would not be surprising to see gypsum as fertilizer duplicate the remarkable history of agricultural lime. Agricultural experts are beginning to point out that lack of sulphur in soils is as serious as lack of phosphorus, for many crops of first importance consume more sulphur than phosphorus, while many soils are more deficient in sulphur than in phosphorus. In Oregon it has been found that large quantities of acid phosphate were being used needlessly on soils containing an abundance of phosphorus, the benefit being derived from the relatively small amount of lime sulphate present in the fertilizer. As soon as this discovery was made, a great saving was made by using a sulphur fertilizer and a considerable tonnage of ground gypsum has been sold in that section in 1918 for use on legumes, especially alfalfa.

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IRON AND STEEL

By E. F. Conn

The history of the American steel industry for 1918 was dominated by one factor—winning the war. It had been predicted long before this country entered the conflict that that country or countries would win the war which predominated in steel and iron output. It was therefore a foregone conclusion that the Allies would win after the United States joined its forces. Steel plus the men won the war.

Aside from maximum war production, the industry was not featured by any unusual happenings. As the year drew to a close, Government price and other control of the industry were abandoned or virtually so, and early in 1919 it became practically a free open market. A schedule of prices was submitted to the War Industries Board by the steel makers in December as a basis for new control prices, but this was rejected, as it had been decided that the Board would pass out of existence on Jan. 1.

With the signing of the armistice production began to slacken, and the industry realized that it had unusual problems before it could return to a peace basis.

Features of the year of a minor nature were the continued expansion of the electric-steel industry, the heavy demand for alloy steels for guns, ordnance, and the quiet but more or less secret development in research problems connected with the industry and fostered by the National Research Council and the Bureau of Mines.

Imports and Exports.—The imports and exports of iron and steel are tabulated below. Exports are not as heayy in 1918 as in 1917, but

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL

(In tons of 2240 lb.)

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Pig iron	120,799	272,676	277,648	114,423	224,509	612,241	656,220	269,527
Billets, blooms, etc.	234,267	294,818	91,847	50,496	560,704	1,504,562	2,017,113	1,786,289
Bars	141,033	230,139	228,331	128,228	465,720	848,479	682 798	642,516
Rails	420,874	446.473	460.553	174,680	391,379	540.349	512,669	453,944
Sheets and plates	372,373	546,968	463,414	280,090	419,637	515,462	831,736	824,886
Structural steel	223,493	288,164	403,264	182,395	232,139	300,594	294,150	232,714
Wire	229,316	244,711	190.282	180,395	473,583	683,025	393,825	392,305
Wire-rods	22,641	65.470	61.636	61,853	165,014	158,284	181,975	148,523
Nails and spikes	77.833	92,497	62.726	49,622	118,349	191,131	159,978	104,311
Pipe and fittings	197,597	249,856	301,784	199,618	176,884	228,573	209,184	140,943

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UNITED STATES IMPORTS OF IRON AND STEEL
(In tons of 2240 lb.)

	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	[1918.
Pig iron	237,233	148,459	129,325	165,450	138,903	89,836	135,349	76,786	34,711
Billets, blooms, etc.	46,578	29,205	18,702	26,675	49,188	14,998	26,142	44,195	41,072
Scrap iron and steel	72,764	17,272	23,612	44,154	34,849	79,982	116,039	180,034	63,730
Bars, iron	43,692	26,729	26,112	28,243	15,015	8,474	7,701	2,240	1,469
Rails	.....	.....	3,780	10,408	22,571	78,525	26,299	9,263	8,705
Wire-rods	20,374	15,483	15,070	16,097	6,954	5,316	4,130	1,006	7,677
Tinplate	66,640	14,099	2,052	20,680	15,411	2,350	1,007	124	32

they were large in all lines directly connected with the war. In some cases they reached record figures in those products entering into the manufacture of munitions. The scarcity of ships, however, affected general results both as to exports and imports, decidedly.

Iron Ore

The iron-ore output of the United States in 1918 dropped to 69,658,278 gross tons, against 75,288,851 gross tons in 1917, according to the figures compiled by Ernest F. Burchard of the United States Geological Survey. This represents a decrease of 7.4 per cent. The figures are also below the 1916 records, but as both 1916 and 1917 were high-water periods in the output of iron ore in the United States, and as 1918 conditions included the severest of war labor shortages, the new records are far from discouraging for the industry.

The shipments of ore from the mines in 1918 amounted to 72,021,202 gross tons, valued at $244,368,147, compared with 75,573,207 tons, valued at $238,260,444 in 1917. The higher prices prevailing last year account for the fact that despite a drop of 4.5 per cent. in the tonnage shipped the valuation figures were 3.3 per cent. higher. The average selling value of ore in the United States at the mines was $3.41 in 1918, against $3.15 in 1917. The apparent decrease in stocks at the mines was 23.4 per cent. from 10,628,908 gross tons in 1917 to 8,139,000 tons in 1918.

The decrease in the output, which was general throughout the country, is probably to be attributed to a combination of circumstances. Industrial conditions were more or less disturbed, the supply of labor was uncertain, and transportation facilities were inadequate. Notwithstanding these handicaps the shipments from the Lake Superior district from April to October inclusive, in 1918, were over 2,500,000 tons more than those for the corresponding period of 1917. Owing to a scaling down

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of furnace requirements, however, to release vessels carrying grain to Europe, the shipments in November and December, 1918, were nearly 4,000,000 tons less than those made in December, 1917. Government control of the entire steel supply, which became effective in June, 1918, undoubtedly regulated the demand for ore, and stocks at mines and lower Lake ports were somewhat reduced, so that the consumption of ore remained about the same as in 1917.

About 86 per cent. of the iron ore mined and shipped in 1918 came from the Lake Superior district, in which about 60,092,000 gross tons was mined and about 62,285,000 tons shipped in 1918, compared with 63,666,068 tons mined and 63,854,752 tons shipped in 1917, representing decreases of 5.6 per cent. and 2.5 per cent. respectively in 1918. The average selling price of iron ore at the mines in the Lake Superior district in 1918 was $3.50 a ton, compared with $3.28 a ton in 1917.

The second largest iron-ore producing area—the Southeastern States—which includes the Birmingham district, mined and shipped in 1918 about 10 per cent. of the grand total. The quantity mined in these States in 1918 is estimated at 6,906,000 gross tons, compared with 8,333,766 tons mined in 1917, and the shipments in 1918 are estimated at 7,249,000 tons, valued at $17,405,000, or $2.40 a ton, compared with 8,396,841 tons, valued at $16;437,775, or $1.96 a ton, in 1917.

The Northeastern States—New Jersey, New York and Pennsylvania—mined in 1918 approximately 1,862,000 gross tons, compared with 2,340,960 tons in 1917, a decrease of 20 per cent., and shipped in 1918 1,821,000 tons, compared with 2,379,393 tons in 1917, a decrease of 23 per cent. The average selling value of the ore in these States in 1918 was $4.91 a ton, compared with $4.45 in 1917.

In the Western States—Colorado, New Mexico, Utah and Wyoming—there was mined about 750,000 gross tons of iron ore in 1918, compared with 837,673 tons in 1917, a decrease of 10 per cent. The shipments in 1918 amounted to approximately 740,000 tons, compared with 832,056 tons in 1917, a decrease of 11 per cent. The average selling value of the ore in this group of States in 1918 was $1.72 a ton, compared with $1.39 a ton in 1917.

The shipments of iron ore by boat during 1918, according to figures compiled by the Lake Superior Iron Ore Association, amounted to 61,156,732 gross tons, and the all-rail shipments to blast furnaces, including those near Duluth, as estimated by the *Iron Trade Review*, amounted to 1,885,000 tons. The Survey figures do not include about 879,000 tons of manganiferous iron ore (ore containing 5 per cent. or more of manganese) mined and shipped from the Lake Superior district in 1918.

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IRON ORE MINED IN THE UNITED STATES IN 1914–1918, GROSS TONS

State.	1914.	1915.	1916.	1917.	1918.
Minnesota	21,946,901	33,464,660	44,585,422	44,595,232	41,953,969
Michigan	10,796,200	12,514,516	8,071,016	17,868,601	16,899,341
Alabama	4,838,959	5,309,354	6,747,901	7,037,707	5,754,624
Wisconsin	886,512	1,095,388	1,304,518	1,202,235	1,089,351
New York	785,377	998,845	1,342,507	1,301,317	906,179
Wyoming	366,962	434,513	545,774	543,846	447,884
New Jersey	350,135	415,234	493,004	481,943	423,525
Pennsylvania	406,326	363,309	559,431	546,700	522,600
Virginia	378,520	348,042	440,492	469,903	414,048
Tennessee	330,214	284,185	455,834	508,529	408,954
Georgia	67,722	115,701	256,949	226,630	264,602
North Carolina	57,667	66,453	64,306	90,997	108,332
Missouri	37,554	40,290	34,914	38,908	72,708
New Mexico	81,980	34,806	157,779	237,221	268,666
Colorado	10,464	*	*	*	7,850
Connecticut	9,149	*	*	*	12,130
Maryland	6,369	5,500	4,455	11,830	8,081
Nevada	*	3,993	9,910	1,010	20,303
Massachusetts	7,600	3,950	*	10,000	8,450
Ohio	5,138	3,455	1,800	.....	.....
California	1,282	646	3,000	2,207	3,107
Kentucky	21,400	.....	.....	.....	.....
West Virginia	6,530	.....	3,605	4,632	.....
Iowa	.....	.....	.....	22,612	7,052
Utah	.....	.....	.....	48,058	52,722
Arkansas	.....	.....	.....	40	.....
Other States†	40,800	23,650	85,055	27,693	2,800
Totals	41,439,761	55,536,490	75,167,672	75,288,851	69,658,278

* Less than three producers in Colorado and Connecticut in 1917, Colorado, Connecticut and Massachusetts in 1916, in Colorado and Connecticut in 1915, and in Nevada in 1914, and permission was not granted to publish State totals.

† 1914: Idaho, Mississippi, Montana, Nevada, and Utah; 1915: Colorado, Connecticut, Idaho, and Utah; 1916: Colorado, Connecticut, Iowa, Massachusetts, and Utah; 1917: Colorado, Connecticut and Montana; 1918: Texas, Washington, Idaho and Montana.

Lake Superior District.[1]—The Lake movement in 1918 was 61,156,732 tons, compared with 62,498,901 tons in 1917, a loss of 1,342,169 tons. The all-rail shipments were 1,679,350 tons, compared with a rail movement of 1,938,102 tons in 1917, a decrease of 258,752 tons or 13.3 per cent. The record of all-rail shipments since 1909 is as follows:

	Gross Tons.		Gross Tons.
1918	1,679,350	1913	876,638
1917	1,938,102	1912	785,769
1916	1,924,268	1911	662,719
1915	953,947	1910	813,639
1914	707,829	1909	903,270

Of the total tonnage moved from the Lake Superior district, independent companies are credited with 58.34 per cent. or 16.68 per cent. more than the shipments of the United States Steel Corp. In 1917 the independents forwarded 55.66 per cent. and in 1916, 52.48 per cent. The 1918 figure exceeds 1917 by 2.68 per cent. and is the highest on record since the formation of the Steel Corporation. Last year was the seventh successive year in which the independent companies have moved more than one-half of the ore shipped from the Lake Superior district. The strength of the independent ore interests is clearly revealed by their

[1] *Iron. Tr. Rev.*, Mar. 6, 1919.

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record of having forwarded more than one-half of the season's tonnage in eight of the last nine years.

The following table shows the shipments and percentages of the Oliver Iron Mining Co., the Steel Corporation's mining organization, for each of the last 10 years;

Year.	Gross Tons.	Percentage.
1909	21,397,866	50.36
1910	21,661,143	49.86
1911	17,282,499	52.70
1912	23,845,363	49.46
1913	24,502,244	49.06
1914	16,039,654	49.01
1915	22,518,613	47.63
1916	31,673,131	47.52
1917	28,571,977	44.34
1918	26,178,782	41.66

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year	Tonnage.
1855...	1,449	1880..	1,948,334	1905..	34,353,456	1910..	43,442,397	1915..	46,994,254
1860...	114,401	1885..	2,466,642	1906..	38,522,239	1911..	32,793,120	1916..	64,734,198
1865...	193,758	1890..	9,003,725	1907..	42,266,668	1912..	46,483,798	1917..	62,498,901
1870...	859,507	1895..	10,429,037	1908..	26,014,987	1913..	52,518,158	1918..	61,156,732.
1875...	881,166	1900..	19,059,393	1909..	42,586,869	1914..	33,629,613	.....	.....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS
(In tons of 2240 lb.)

Range.	1913.	1914.	1915.	1916.	1917.	1918.
Marquette.....	3,966,680	2,491,857	4,105,378	5,396,007	4,874,150	4,354,207
Menominee.....	4,965,604	3,221,258	4,982,626	6,364,363	6,045,750	6,378,698
Gogebic.....	4,531,558	3,568,482	5,477,767	8,489,685	7,981,684	7,936,701
Vermillion.....	1,566,600	1,016,993	1,733,595	1,947,200	1,530,692	1,192,908
Mesabi.....	34,038,643	21,465,967	29,756,689	42,525,612	41,445,211	40,396,711
Baraboo.....	145,010	105,765	80,583	1,716,218	136,632	98,057
Cuyuna.....	733,021	859,404	1,136,113	219,381	2,422,884	2,478,000
Total.....	49,947,116	32,729,726	47,272,751	66,658,466	64,437,003	62,836,082

Iron-ore shipments from the Mesabi range in 1918 amounted to 40,396,711 tons, as against 41,445,211 tons in 1917, a loss of 1,048,500 tons. Its percentage of the total shipments was 64.29, or practically the same as the 1917 percentage of 64.32. In 1916, this range shipped 63.80 per cent.; 62.95 in 1915; and 65.62 in 1914. The Gogebic range was again the second largest shipper, forwarding 7,936,701 tons, a loss of 44,983 tons compared with the 1917 total of 7,981,684 tons. Its percentage for 1918 was 12.63, as against 12.39 in 1917; 12.74 in 1916; 11.59 in 1915; and 10.90 in 1914. Shipments from the Marquette range also fell below the tonnage reported for the previous year. The movement

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from this range amounted to 4,354,207 tons, and in 1917 it was 4,874,150 tons, a loss of 519,943 tons. Its percentage was 6.93, compared with 7.56 in 1917; 8.09 in 1916; 8.68 in 1915; and 7.61 in 1914. The Vermillion range shipments totaled 1,192,908 tons, a loss of 337,784 tons compared with 1917, when it forwarded 1,530,692 tons. Its percentage was 1.90 against 2.38 in 1917; 2.92 in 1916; 3.67 in 1915; and 3.10 in 1914.

Although the Menominee and Cuyuna ranges were the only ones forwarding a larger tonnage of ore than in the previous year, shipments from all ranges, except the Vermillion, ran well above the average maintained in the years immediately before the war. Menominee shipments increased to 6,378,698 tons, or 332,948 tons above the 1917 figure of 6,045,750 tons. Its percentage was 10.15, as against 9.38 in 1917; 9.55 in 1916; 10.54 in 1915; and 9.83 in 1914.

Shipments from the Cuyuna range continue to increase and were more than double those from the Vermillion, which it exceeded for the first time in the previous year. The tonnage forwarded from the Cuyuna last year reached a total of 2,478,800 tons, a gain of 55,916 tons compared with the 1917 total of 2,422,884 tons. The Cuyuna's percentage of the total shipments in 1918 was 3.94, compared with 3.74 in 1917, and 2.57 in 1916. In 1915, the Cuyuna's percentage was 2.40, and in 1914, 2.62.

Twelve mines shipped more than 1,000,000 tons last year, these mines being the Adams, Canisteo, Fayal, Hull-Rust, Kerr, Mahoning, Missabe Mountain, and Morris, on the Mesabi; Newport, Norrie Group and Wakefield, on the Gogebic; and Cleveland-Cliffs group on the Marquette. In 1917, 11 mines shipped more than 1,000,000 tons, these being the Adams, Canisteo, Fayal, Hull-Rust, Kerr, Mahoning, Morris and Sellers on the Mesabi; Newport, Norrie group and Wakefield on the Gogebic.

Although shipments from the Hull-Rust mine fell off somewhat last year, the tonnage forwarded by that mine was again an exceedingly large one. This mine shipped 5,452,585 tons, which is considerably above the total shipments from the Marquette, Vermillion or Cuyuna ranges, and is less than 1,000,000 tons below the Menominee shipments. Shipments from the Hull-Rust in 1917 were 6,461,443 tons, and in 1916, 7,665,611 tons.

Two other mines shipped more than 2,000,000 tons last year, the Kerr, with 2,027,589 tons, and the Mahoning, with 2,024,675 tons. The Mahoning was the leading shipper in 1915, with 2,311,940 tons. The Hull-Rust has been the leading shipper in nine of the last 12 years, the Hill leading in 1911, and the Leonard in 1914.

The following new mines shipped in 1918:

On the Mesabi: Burns, of the Bowe-Burke Mining Co.; Margaret, of

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Butler Bros.; Wade, of Cleveland-Cliffs Iron Co.; and Wisstar, of Clement K. Quinn.

SHIPMENTS BY PORTS AND ALL-RAIL
(Gross tons)

	1913.	1914.	1915.	1916.	1917.	1918.
Escanaba	5,399,444	3,664,451	5,649,289	7,457,444	7,156,854	6,774,969
Marquette	3,137,617	1,755,726	3,099,589	3,858,092	3,207,145	3,457,054
Ashland	4,338,230	3,363,419	5,146,772	8,057,814	7,597,841	7,565,608
Two Harbors	10,075,718	5,610,262	8,642,942	10,735,853	9,990,901	8,723,472
Superior	13,788,343	11,309,748	8,342,793	12,787,046	13,978,741	14,068,341
Duluth	12,331,126	6,318,291	15,437,419	21,837,949	20,567,419	20,567,288
Total by lake	49,070,478	32,021,897	46,318,804	64,734,198	62,498,901	61,156,732
Total by rail	876,638	707,829	953,947	1,924,268	1,938,102	1,679,350
Total	49,947,116	32,729,726	47,272,751	66,658,466	64,437,003	62,836,082

On the Marquette: Athens, Bunker Hill, and Francis, of the Cleveland-Cliffs Iron Co., and Maitland, of the Maitland Mining Co.

On the Cuyuna: Adams of the Biwango Mining Co.; Arko, Hopkins and Martin, of Clement K. Quinn; Bonnie Belle, of the Liberty Mining Co.; Brainerd-Cuyuna, of the Brainerd-Cuyuna Mining Co.; and Ida Mae, of the Merritt Development Co.

The total of 15 new shippers in 1918 is five less than in 1917, and seven less than in either 1916 or 1915, when the number of new mines opened was 22. In 1914 there were 16 new mines opened; 20 in 1913, and 13 in 1912. Four of the mines shipping for the first time last year are located on the Mesabi, four on the Marquette, and seven on the Cuyuna. Shipments from new mines totaled 341,085 tons in 1918, compared with 1,737,759 tons in 1917. In 1916 these shipments totaled 2,357,850 tons; 1,203,213 in 1915, and 677,182 tons in 1914.

Shipments from the Canadian mines in 1918 were as follows: Helen, of the Algoma Steel Corp., 4221 tons; Magpie, of the Algoma Steel Corp., 156,790 tons; and Moose Mountain, of Oglebay, Norton & Co., 26,777 tons. The Helen shipped 90,059 tons in 1917, 37,272 tons in 1916, and 220,771 tons in 1915. The Moose Mountain, which was idle in 1917, shipped 5338 tons in 1916, and 40,444 tons in 1915. The Magpie shipped 174,774 tons in 1917, 187,809 tons in 1916, and 107,560 tons in 1915. The shipments from the Canadian mines are not included in the total for the Lake Superior ore shipments.

In 1918 shipments were forwarded from 284 mines, compared with 246 in 1917. In 1916 there were 233 mines, 209 in 1915, 196 in 1914, 223 in 1913. Of those shipping last year, the Mesabi had 135, the Menominee 49, the Marquette 33, the Cuyuna 29, the Gogebic 27, the Vermillion 9 and the Mayville-Baraboo 2. In 1917, the Mesabi shippers numbered 122, the Menominee 41, Marquette 25, Gogebic 27, Cuyuna 21, Vermillion 8, and Mayville-Baraboo 2.

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LEADING SHIPPERS OF THE LAKE SUPERIOR DISTRICT

	1914.	1915.	1916.	1917.	1918.
Mesabi:					
Burt	213,433	1,043,607	1,060,487	692,017	747,968
Canisteo	1,051,895	1,622,182	1,943,745	1,643,226	1,426,399
Fayal	.....	774,096	2,288,799	2,037,705	1,366,083
Hull-Rust	458,468	2,294,405	7,665,611	6,461,443	5,452,585
Leonard	2,687,285	197,599	316,468	305,537	737,209
Leonidas	.....	732,777	1,147,105	795,826	656,735
Mahoning	1,212,287	2,311,940	2,215,788	2,524,110	2,024,595
Morris	365	1,167,421	1,609,971	1,605,701	1,044,558
Sauntry-Alpena	1,131,255	1,455,825	933,937	596,049	531,427
Sellers	.....	721,908	1,344,121	1,575,057	865,070
Menominee:					
Bristol	.....	378,786	462,559	188,907	245,151
Caspian	279,379	479,084	448,631	411,705	346,028
Chapin	340,722	384,654	557,485	682,349	705,803
Marquette:					
Cleveland-Cliffs	673,160	634,837	1,036,775	946,410	1,050,147
Negaunee	.....	480,521	523,736	573,760	501,965
Gogebic:					
Montreal	.....	464,272	530,813	458,658	298,896
Newport	.....	838,875	1,315,980	1,003,229	1,041,697
Norrie Group	984,242	1,408,516	1,855,863	1,646,606	1,550,802
Wakefield	.....	651,302	1,061,730	1,144,411	1,130,432
Vermillion:					
Pioneer	.....	453,099	507,086	352,497	260,516
Zenith	424,110	714,852	482,783	382,666	243,093
Cuyuna:					
Armour No. 2	283,565	303,280	341,147	273,812	246,362
Pennington	.....	117,068	206,085	165,895	164,269
Mayville-Baraboo:					
Mayville	103,549	80,583	125,970	93,997	88,812

The following table shows the average shipments of all mines on the six leading ranges and of the whole Lake Superior district for 1914–18.

AVERAGE MINE SHIPMENTS

	1914.	1915.	1916.	1917.	1918.
Mesabi	228,361	306,769	397,436	339,715	299,235
Vermillion	169,499	247,656	243,400	191,336	132,545
Gogebic	169,928	210,683	339,585	295,618	293,952
Marquette	99,674	146,621	119,852	194,966	131,946
Menominee	78,567	124,566	141,430	147,457	130,177
Cuyuna	122,772	113,611	95,345	115,375	85,476
Lake Superior district	166,988	226,186	286,087	261,939	222,475

FOREIGN ORE IMPORTS DURING LAST SIX YEARS

Country from Which Exported.	1913.	1914.	1915.	1916.	1917.	1918.
Cuba	1,635,622	815,017	831,618	716,571	546,069	632,442
Sweden	356,074	280,887	204,632	212,063	63,715	.....
Spain	112,580	66,982	42,092	161,422	152,713	38,385
Chile	.....	45,000	146,000	.....	.....	.....
Canada	179,860	52,514	84,124	136,835	178,785	115,354
Africa	12,950	46,175	22,000	.....	.....	.....
Miscellaneous	297,684	44,793	10,815	98,845	30,381	1,287
	2,594,770	1,351,368	1,341,281	1,325,736	971,663	787,468

Exports.—Exports of iron ore from the United States in 1918 amounted to 1,256,431 gross tons, as compared with 1,132,313 tons in 1917 and 1,183,952 tons in 1916.

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Manganese Ore and Alloys in 1918.—Another record was made by the American manganese-iron alloy industry in 1918. The domestic output of both ferromanganese and spiegeleisen by the blast furnaces and electric furnaces has steadily grown since 1913.

The analysis of the situation as to ferromanganese supplies and needs in *The Iron Age*, Dec. 26, 1918, still holds. At that time it was estimated theoretically that with a steel output of 45,000,000 tons of ingots and castings in 1918, about 351,000 tons of 70-per cent. alloy would be required. The actual output was over 345,000 tons, indicating practically no shortage and no oversupply, according to the theoretical estimate.

Details concerning manganese ore and alloys are given in the chapter on "Manganese" in this volume.

Iron and Steel Markets

Pittsburgh.[1]—Government price regulation of the iron and steel industry in 1918 worked fairly smoothly. Arguments were made from time to time that higher prices should be allowed, but much of the talk indulged in was doubtless for the purpose of forestalling reductions which the authorities might have had in mind. The great majority of producers made large profits, subject to heavy taxes, though a few small producers had only a scant margin, and were less subject to taxation.

The important finished steel products were unchanged as to price during the period of Government control, though two changes were made in pig iron in 1918, one being a reduction and the other an advance.

The year opened with pig iron at a base price of $33, f.o.b. furnace, Bessemer being 10 per cent. higher, or $36.30. Foundry iron containing 1.75 to 2.25 per cent. silicon sold at base price, and the No. 2X made by Eastern furnaces, running 2.25 to 2.75 per cent., was 50 cts. higher, or $33.50. On Apr. 1, basic iron was reduced $1, to $32, Bessemer being still 10 per cent. above basic, or $35.20. On Oct. 1, the basic price of pig iron was increased $1, but this did not apply to Bessemer. The advance on foundry iron with silicon 2.25 to 2.75 per cent. was increased from 50 cts. to $1.25. Eastern Pennsylvania furnaces were given a Pittsburgh basing, and Virginia and Tennessee a Birmingham basing, whereby the furnaces mentioned experienced a separate and additional advance. Government prices continued to the end of the year 1918, with no definite prospect of a decline.

The last quarterly meeting between the War Industries Board and the general committee of the American Iron and Steel Institute was held on Dec. 11. The committee attended the meeting prepared to submit a schedule of price reductions to rule for the first quarter of the new year,

[1] B. E. V. Luty, *Eng. Min. Jour.*, Jan. 11, 1919.

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but, not much to the surprise of the committee, the War Industries Board refused to have the statement even read into the minutes, explaining that it was through price fixing. The statement was thereupon given to the press. The steel producers immediately began quoting the suggested reduced prices, but the pig-iron producers did not recognize the $3 reduction suggested for pig iron. The accompanying table shows average prices in 1917, Government prices and the reduced prices effective after the meeting of Dec. 11 for 1918.

PRICES OF STEEL PRODUCTS

	1917.	1918.	
		Government.	Reduced.
Billets, per gross ton	$71.16	$47.50	$43.50
Beams per 100 lb	3.66	3.00	2.80
Plates, per 100 lb	5.21	3.25	3.00
Bars, per 100 lb	3.49	2.90	2.70
Black sheets, 28 gage, per 100 lb	6.29	5.00	4.70
Pipe, discount from list, per cent	52½	51	54
Wire nails, per keg	$3.56	$3.50	$3.50

During Government control ferromanganese stood at $250, delivered, for 70 per cent., as the result of an informal understanding. At the close of 1918 a new market price had not been definitely established.

At the beginning of 1918, the War Industries Board was exercising only a limited amount of control over the distribution of iron and steel, its regulations pertaining chiefly to prices. By reason of growing needs for steel, and the reduced rate at which steel was made early in the year, it became necessary that the steel industry should recognize more fully the war-time requirements, and the Director of Steel Supply had to make the industry fully acquainted with the fact. At a meeting held on Apr. 26, the iron and steel producers took a "100 per cent. efficiency pledge," promising their entire efforts would be directed toward helping to win the war.

In June the scheme of distribution, which had previously covered only a certain number of priorities, was greatly extended, and in July "automatic priority" was provided for many cases in which previously it had been necessary for the War Industries Board to issue individual priorities. The sequence of importance was as follows: Class AA priorities, Class A priorities, Class B priorities, Class C, or preference steel, and Class D, or permit steel. No steel could be manufactured or shipped against a given class of orders until provision had been made that all steel of a higher order would be made and shipped within the time required by the buyer. The preference list was a "list of purposes entitled to preference treatment." After priorities and preference wants were fully met, pro-

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ducers could make and ship Class D steel, upon written permission, for purposes not recognized as essential.

An important thing that this distribution system showed was that steel is the backbone of industry, for when nearly all industries were summoned to help win the war they required more steel than could be made.

There was a shortage, yet there were few industries that were denied steel.

Larger wage advances occurred in 1918 than in either of the two preceding years. From the general wage advance of Feb. 1, 1913, to the beginning of 1916 there was no general change in wage rates in the iron and steel industry. Wage advances during the war period occurred as follows: 1916, Feb. 1, May 1, Dec. 15; 1917, May 1, Oct. 1; 1918, Apr. 15, Aug. 1, Oct. 1. All these advances averaged about 10 per cent. each, except that the advance of Apr. 15, 1918, was about 15 per cent., and the advance of Oct. 1, 1918, was chiefly the establishment of the basic 8-hr. day system of payment, providing 14 hours' pay for 12 hours' work and 11 hours' pay for 10 hours' work, with some advances to 8-hr. men to equalize. The standard hourly rate in 1915 was about 19 cts. for common labor, this increasing to about 42 cts., Aug. 1, 1918, though after the establishment of the 8-hr. basic day 12-hr. men received an actual average of 49 cts. per hour, or two and one-half times the rate in 1915.

Though such wages appeared excessive, no way to effect a reduction presented itself at the close of the war. The iron and steel industry sought to secure more efficient performance as one means of reducing its extremely high wage cost per ton. As to its business prospects, the industry recognized that the cost of putting steel into employment was extremely high, through high wage rates and indifferent performance of labor in the building and other trades consuming steel, and that this would have a great influence upon investors in permanent construction work.

Chicago.[1]—Production, not selling, was the chief concern of the iron and steel industry in 1918. Until hostilities ended, war requirements gained in volume until almost overwhelming, and with the Government directing where material should go through its priority regulations and system of allocating, the great thing was to maintain and, if possible, increase output, meanwhile keeping the Government informed.

In a little more than six weeks, conditions underwent a tremendous reversal. Prior to the declaration of the armistice, the mills would not promise delivery for months to come, except to those who held high priority ratings, but not long after the announcement that fighting had ceased, gaps in rolling schedules loomed up as an immediate probability,

[1] Charles Lundberg, *Iron Age*, Jan. 2, 1919.

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with all that this entails. Consumers immediately took the stand they were entitled to assurances protecting them from loss in case of price declines, while the mills at first sought to stipulate that settlements on deliveries in 1919 would be made on the basis of the last-named Government maximum. Then the counsel of wise leaders was heeded, and that prices should be lowered was generally conceded.

Many fears on the part of consumers were not realized. While the operations of some so-called non-essential industries were curtailed, complaint that those who were entitled to material had been neglected were negligible, a fact partly explained by the degree to which essential work became general and the efficacy of allocations by the War Industries Board.

In the first few weeks of the year, operations of all kinds were greatly hampered by exceptionally heavy storms and snowfalls and a shortage of coke resulting from severe weather and inadequate or interrupted rail facilities. Poor coke also was a deterrent, but finally the industry struck its stride, and it was going at practically full capacity when war contracts were canceled. With the annulment of priorities, the discontinuance of allocations and the release of jobbers from the war pledge in late November, orders began to take their regular order of precedence, except where ship, railroad and Government material was involved.

It is not necessary to say much of plates, more than that ship and car demands, and especially the former, took practically the full output of the year. At times it was difficult to see how Government needs could be fully met. The demand for hull steel is still great, but the pressure for deliveries is easier, and the outlook for industrial purposes is encouraging.

In shapes and bars, the situation for the domestic consumer was a little less acute than in plates. The structural fabricating shops were saved from disaster by the ship work allotted to them, inasmuch as ordinary building construction was under the ban, unless of an essential character. In late July, a feature of the steel-bar market was a reduction of $5 per ton granted the makers of agricultural implements at the instance of the Government. It was argued the farmer could not pay more for his machines and that the implement makers did not have a safe margin of profit.

Bar iron was to some extent substituted for mild steel bars, but not to the extent to which the makers had hoped, although late in the year their books became comfortably filled with orders which, however, did not extend far into the future. At times bar-iron capacity was idle, despite energetic effort to have bar iron used in the building of freight cars to a greater extent than is customary.

In the second quarter, Chicago was a basing point along with Pittsburgh, but the end of the quarter brought the single basing point again,

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that, of course, being Pittsburgh. Later in the year, Western consumers, largely structural fabricators, sought to have the dual base re-established, but without success.

From the early part of the year until near its close, jobbers in iron and steel faced a perplexing problem in replenishing their stocks under the B-4 priority rating given to them. This was of little avail, despite the pledge they have given to conserve steel for war use. Having precedence was a huge quantity of steel with higher ratings. A plan was finally evolved whereby the jobbers were authorized to replace stock to the extent they had sold for essential needs in the previous month, but still their supply was disappointing and deliveries uncertain.

Consumers of pig iron, more particularly the larger ones, pursued a policy of buying well into the future. They bought early and generously for the last half of 1918, and in August for the first half of 1919. Coincident with the later buying there were many allocations to those having war orders, these being invariably cemented by formal contracts, and when the general cancellation of war contracts came, the pig-iron producers held that their contracts were non-cancellable in accordance with tradition.

PIG IRON, FINISHED IRON AND STEEL AND SCRAP, CHICAGO (a)

	Northern Coke No. 2.	Lake Superior Charcoal.	Southern Coke No. 2.	Common Bar Iron, Cents.	Soft Steel Bars, Cents.	Structural Steel, Cents.	Cast Borings, Net Ton.	No. 1 Railroad Wrought, Net Ton.	Heavy Cast Scrap, Net Ton.	Heavy Melting Steel Scrap, Gross Ton.	Old Steel Rails, Rerolling, Gross Ton.
January	$30.00	$31.75	$27.00	3.00	3.189	3.239	9.00	$23.50	$15.50	$21.12	$27.00
February	31.25	33.75	27.50	3.00	3.189	3.439	9.06	23.75	15.37	21.50	27.00
March	35.40	36.75	32.60	3.02	3.459	3.649	9.50	25.90	16.90	23.70	28.00
April	39.25	40.25	37.75	3.25	3.699	3.989	10.56	30.25	20.43	27.00	32.62
May	43.80	48.15	42.40	3.40	3.939	4.539	12.00	32.60	23.20	28.70	36.50
June	50.37	52.88	46.00	4.02	4.379	5.629	17.50	41.00	30.00	36.50	46.90
July	55.00	57.75	52.75	4.50	4.689	6.189	17.87	37.75	29.25	33.00	45.19
August	55.00	58.00	54.00	4.50	4.689	6.189	16.40	33.70	24.20	29.60	39.20
September	54.50	58.00	53.50	4.50	4.689	4.689	16.25	35.50	23.75	31.25	39.75
October	33.00	37.50	37.00	4.50	3.115	3.215	14.06	28.75	20.50	26.00	34.75
November	33.00	37.50	37.00	4.00	3.115	3.215	15.40	30.90	22.00	27.60	34.80
December	33.00	37.50	37.00	3.50	3.115	3.215	16.12	31.25	23.50	28.37	35.25
Averages:											
1918	33.25	37.88	37.75	3.50	3.08	3.18	15.94	29.77	27.71	28.81	33.71
1917	41.13	44.14	40.38	3.77	3.772	4.275	13.64	30.40	20.05	27.86	34.74
1916	20.25	21.33	19.85	2.31	2.94	2.83	6.98	17.16	13.10	16.68	18.59
1915	14.02	16.10	14.73	1.24	1.48	1.48	5.57	10.27	9.96	10.91	11.73
1914	13.60	15.60	14.46	1.06	1.32	1.34	4.61	8.66	9.70	9.37	10.96
1913	15.95	16.50	16.12	1.43	1.55	1.60	5.36	10.80	10.44	10.90	13.33
1912	15.32	16.77	16.11	1.32	1.42	1.46	6.67	12.54	12.29	12.12	14.19
1911	14.87	16.96	14.80	1.22	1.47	1.50	5.34	11.23	11.08	10.92	12.91
1910	17.10	18.67	16.30	1.45	1.62	1.66	5.50	12.99	13.32	13.43	16.34
1909	17.49	19.50	17.30	1.43	1.50	1.59	6.37	13.76	13.79	14.45	15.82
1908	17.57	20.24	16.76	1.56	1.66	1.82	5.37	12.45	12.69	12.45	14.40
1907	24.50	26.56	24.47	1.78	1.77	1.87	8.78	14.63	17.26	15.08	17.53
1906	20.43	20.72	19.44	1.71	1.68	1.86	8.69	15.62	14.55	14.74	17.15
1905	17.65	17.99	16.66	1.65	1.65	1.78	8.57	16.14	13.50	13.97	15.02
1904	14.37	15.50	15.92	1.41	1.50	1.71	4.72	12.45	10.95	10.72	12.54
1903	19.25	22.13	18.31	1.65	1.72	1.75	7.33	16.07	14.75	15.50	19.04
1902	20.86	23.50	20.10	1.71	1.73	1.75	8.89	19.68	15.03	17.37	23.35
1901	15.38	17.50	14.60	1.58	1.58	1.70	4.20	15.00	11.25	12.84	16.05
1900	19.47	22.00	18.35	1.75	1.75	2.00	6.65	15.00	11.00	12.84	15.50

(a) *Iron Age.*

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Throughout the year the distribution of iron was thoroughly regulated, though at first producers were allowed to use judgment as to the essential character of the demand; then the Government took full control, and, aside from allocating, frequently sent letters urging shipments from furnaces which appeared to be dilatory, though usually the iron in question was in transit.

Early in the year, a shortage of pig iron was predicted and feared, but no actual shut-downs for want of iron came to light, although at times a stoppage seemed perilously near because of delayed shipments. Had the war lasted a few months longer, the expected shortage probably would have developed, inasmuch as the semi-steel shell program alone would have called for several hundred thousand tons. With the flood of war cancellations, the problem became one of what many foundries would do with the iron they were committed to take.

In the course of the year, nearly all items of scrap reached the allowable maximums, and to give the dealers a profit under these circumstances a commission of 3½ per cent. was permitted. The railroads, while prices were at maximum levels, in many instances sold direct to consumers. Considerable quantities of scrap were at times shipped from the Chicago territory to districts where there was a scarcity, permission to do this having been granted by the Sub-committee of Scrap Iron and Steel. In Chicago, prior to the armistice, there was much talk of scarcity, but an amazing amount of material appeared when the prospect of a lessened demand came in sight.

The sensitiveness of the old material market was exemplified by the manner in which it weakened with the first peace talk in October. In early November, consumers had become exceedingly conservative, and by the middle of that month the market was at a standstill except for transactions within the trade. Thereupon prices crumbled.

Pig Iron

The production of pig iron in the United States in 1918 was 39,051,991 gross tons of all kinds, which compares with 38,621,216 tons in 1917 and 39,434,797 tons in the record year of 1916. The production in the second half of 1917 was only 30,927 tons more than in the first half, but in the second half of 1918 the production was 20,824,261 tons, or 2,596,522 tons more than in the first half. The production in the first half of 1918 was 18,227,730 tons, or 1,022,505 tons less than in the first half of 1917. The decreased production in the first half of last year was due to the extremely cold weather and snow which prevailed early in the year. Had it not been for influenza, which prevailed during a number of weeks of the

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last half of the year, the record for the last half of 1918 would undoubtedly have been considerably better.

The increase in production in 1918 as compared with 1917 was only 1.12 per cent., but it extended to all grades except Bessemer and low phosphorus, which declined 5.03 per cent., and foundry and ferrosilicon, which declined 3.48 per cent. The largest increase was 47.09 per cent. in spiegeleisen and 28.03 per cent. in ferromanganese.

The detailed statistics of pig-iron production in 1918 show a total output much below the capacity.[1] The 1916 output, 39,434,797 gross tons, stands as the record, 1917 having shown only 38,621,216 tons, and 1918, 39,051,991 tons. With four new blast furnaces completed in 1916, 14 in 1917 and eight in 1918, the production last year under favorable manufacturing conditions might have been 44,000,000 tons.

Comparing 1916 with 1918, there was a decrease of 1.35 per cent. in the production of Bessemer and basic iron, from 32,106,544 tons to 31,671,140 tons, while there was an increase of 1.96 per cent. in the production of steel ingots. This was due to more pig iron passing through the open-hearth furnace and less through the Bessemer converter, as there was a decrease of about 1,400,000 tons in the output of Bessemer iron and an increase of about 1,000,000 tons in the output of basic iron. The production of steel ingots increased 810,000 tons, from 41,400,000 tons in 1916 to 42,210,000 tons in 1918. If ingot production in 1918 had borne the same relation to Bessemer and basic pig-iron production as obtained in 1916, the ingot total would have been 1,375,000 tons less than it was. This effectually disposes of the claims so frequently made in 1918 that scrap was in very short supply. The ingot tonnage could not have been made if there had not been the scrap. Scrap was simply scarce in relation to the demand for it, for the works wanted much more than usual. Furthermore, a shortage in heavy melting steel was frequently referred to as a shortage of scrap in general. Mills used lower grades of scrap, when they would have preferred good, heavy melting steel.

Continuing the comparison between 1916 and 1918, since in the one year the United States was not in the war and in the other year it was, it may be observed that the production of pig iron of other grades than Bessemer and basic showed no material change. Foundry-iron production decreased slightly, while production of malleable and forge increased somewhat. Foundry-iron production decreased 7 per cent., while malleable production increased 20 per cent., but the increase did not count for much in point of tonnage.

For a longer-range comparison, however, it may be noted that in 1916, 1917 and 1918, when the demand was heavy for war material, the pro-

[1] *Iron Age.*

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duction of foundry iron averaged 5,300,000 tons a year, while that same amount had been produced in 1909, when the total production of pig iron was precisely two-thirds what it averaged in the past three years. One might infer that the steel casting was replacing the iron casting, but this it is not doing to any great extent. The more applicable explanation is that consumption of rolled steel increases much more rapidly than consumption of iron castings, and somewhat more rapidly than consumption of steel castings.

MONTHLY PRODUCTION OF PIG IRON, LONG TONS

	1914.	1915.	1916.	1917.	1918.
January	1,879,336	1,591,024	3,185,121	3,150,938	2,411,768
February	1,888,607	1,666,592	3,087,212	2,645,247	2,319,299
March	2,341,551	2,046,280	3,337,691	3,251,352	3,213,091
April	2,261,501	2,114,518	3,227,768	3,334,960	3,288,211
May	2,097,019	2,255,157	3,361,073	3,417,340	3,446,412
June	1,904,566	2,369,932	3,211,588	3,270,055	3,323,791
Total first half	12,372,580	12,043,503	19,410,453	19,069,892	18,002,572
July	1,955,324	2,563,311	3,224,513	3,342,438	3,420,988
August	1,996,483	2,774,825	3,203,713	3,247,947	3,389,585
September	1,882,718	2,834,342	3,202,366	3,133,954	3,418,270
October	1,767,227	3,120,340	3,508,849	3,303,038	3,486,941
November	1,501,269	3,035,235	3,311,811	3,205,794	3,354,074
December	1,495,325	3,201,605	3,171,087	2,882,918	3,433,617
Total second half	10,598,346	17,529,658	19,622,339	19,116,089	20,503,675
Grand total(a)	22,970,926	29,573,161	39,032,792	38,185,981	38,506,247

(a) These totals do not include charcoal pig iron.

Pig-iron output in the United States since 1820 is given in the following table:

PIG-IRON PRODUCTION FOR 100 YEARS
(Long Tons)

1820	20,000	1861	653,164	1882	4,623,323	1903	18,009,252
1828	130,000	1862	703,270	1883	4,595,510	1904	16,497,033
1829	142,000	1863	846,075	1884	4,097,888	1905	22,992,380
1830	165,000	1864	1,014,282	1885	4,044,526	1906	25,307,191
1831	191,000	1865	831,770	1886	5,683,329	1907	25,781,361
1832	200,000	1866	1,205,663	1887	6,417,148	1908	15,936,018
1840	286,903	1867	1,305,023	1888	6,489,738	1909	25,795,471
1842	215,000	1868	1,431,250	1889	7,603,642	1910	27,303,567
1846	765,000	1869	1,711,287	1890	9,202,703	1911	23,649,547
1847	800,000	1870	1,665,179	1891	8,279,870	1912	29,726,937
1848	800,000	1871	1,706,793	1892	9,157,000	1913	30,966,301
1849	650,000	1872	2,548,713	1893	7,124,502	1914	23,332,244
1850	563,755	1873	2,560,963	1894	6,657,388	1915	29,916,213
1852	500,000	1874	2,401,262	1895	9,446,308	1916	39,434,797
1854	657,337	1875	2,023,733	1896	8,623,127	1917	38,621,216
1855	700,159	1876	1,868,961	1897	9,652,680	1918	39,051,991
1856	788,515	1877	2,066,594	1898	11,773,934		
1857	712,640	1878	2,301,215	1899	13,620,703		
1858	629,548	1879	2,741,853	1900	13,789,242		
1859	750,650	1880	3,835,191	1901	15,878,354		
1860	821,223	1881	4,144,254	1902	17,821,307		

Below is given the production by half-yearly periods for 1913 to 1918, in gross tons, as compiled by the American Iron and Steel Institute. All pig iron and ferro-alloys are included, whether made in blast furnaces or in electric furnaces.

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Periods.	1913.	1914.	1915.	1916.	1917.	1918.
First half	16,488,602	12,536,094	12,233,791	19,619,522	19,258,135	18,227,730
Second half	14,476,699	10,796,150	17,682,422	19,815,275	19,389,262	20,824,261
Total	30,966,301	23,332,244	29,916,213	39,434,797	38,647,397	39,051,991

The only important decreases in production were in Pennsylvania and Alabama, as is shown in the following table of production by States.

PRODUCTION OF PIG IRON BY STATES
(In tons of 2240 lb.)

States.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Massachusetts and Connecticut	17,366	12,810	6,594	7,802	5,719	10,527	11,485
New York	1,939,231	2,187,620	1,559,864	2,104,780	2,352,535	2,417,529	2,877,118
New Jersey	36,876						
Pennsylvania	12,552,131	12,954,940	9,733,369	12,790,668	16,506,824	15,539,728	15,198,271
Maryland	219,546	289,959	195,594	251,548	501,452	422,212	373,817
Virginia	256,167	341,815	271,228	251,346	399,885	520,311	513,737
Alabama	1,862,681	2,057,911	1,826,929	2,049,453	2,762,885	2,953,705	2,587,852
N. Car., Geo., Texas	*Nil.*	.....	.....	.....	.....	.....	.....
West Virginia	274,360	315,731	(b)236,393	(b)291,040	(b)554,590	561,951	594,675
Kentucky	68,760						
Tennessee	338,238	280,541	216,738	177,729	355,374	369,951	369,822
Ohio	6,802,493	7,129,525	5,283,426	6,912,962	8,602,895	8,518,603	8,764,132
Illinois	2,887,359	(a)2,927,977	1,847,451	2,447,220	3,922,512	3,456,915	3,440,307
Michigan	(a)1,770,628	1,775,883	(a)1,557,355	a1,986,778	(a)2,221,708	2,657,503	3,703,599
Wisconsin, Minn.	303,370	367,326	329,526	372,966	811,325	738,541	750,366
W. of Miss. River	397,731	324,263	267,777	271,921	437,633	453,742	502,810
Total	29,726,937	30,966,301	23,332,244	29,916,213	39,434,797	38,621,216	39,051,991

(a) Includes Indiana. (b) Includes Mississippi.

Production of pig iron from 1912 to 1918 according to fuel used is given below:

PIG-IRON PRODUCTION ACCORDING TO THE FUEL USED
(In tons of 2240 lb.)

Fuel Used.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Coke(a)	29,132,733	30,348,973	22,976,856	29,535,308	38,844,598	37,889,824	38,421,175
Anthracite & coke	236,467	254,901	91,464	84,753	217,788	381,048	283,592
Anthracite alone	10,712	22,446					
Charcoal	347,025	339,981	263,924	296,152	372,411	376,523	347,224
Charcoal & coke							
Total	29,726,937	30,966,301	23,332,244	29,916,213	39,434,797	38,647,397	39,051,991

(a) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke.

Iron made with coke includes ferro-alloys made with electricity.

Below is listed the production of pig iron according to character of product. Low-phosphorus pig iron, that is, running under 0.04 per cent. phosphorus, is included in Bessemer pig iron; the latter is iron containing from 0.04 to 0.10 per cent. phosphorus. The figures for the last 4 years

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include under basic iron a small quantity of charcoal iron of basic grade. Nearly all of the charcoal iron is classed as foundry iron; pig iron of high silicon content is included in the foundry group, while under "all other grades" are included white and mottled iron, direct castings, and miscellaneous ferro-alloys.

PRODUCTION OF PIG IRON BY GRADES, 1909–1918

Years.	Basic.	Bessemer.	Foundry.	Malleable.	Forge.	All Other.	Total, Gross Tons.
1909	8,250,225	10,557,370	5,322,415	658,048	725,624	281,789	25,795,471
1910	9,084,608	11,245,642	5,260,447	843,123	564,157	305,590	27,303,567
1911	8,520,020	9,409,303	4,468,940	612,533	408,841	229,910	23,649,547
1912	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244
1915	13,093,214	10,523,306	4,864,348	829,921	316,214	289,210	29,916,213
1916	17,684,087	14,422,457	5,553,644	921,486	348,344	504,779	39,434,797
1917	17,671,662	13,714,732	5,328,258	1,015,579	345,579	545,278	38,621,216
1918	18,646,174	13,024,966	5,142,607	1,117,914	393,932	726,398	39,051,991

This table shows the heaviest decreases in Bessemer and foundry grades, the basic nearly holding its own as compared with 1917.

Of the 39,051,991 tons of pig iron made in 1918, 10,765,887 tons, or 27.6 per cent., was for sale, and 28,286,104 tons was for the maker's use; in 1917 the proportion for sale was 30.2 per cent.

The number of blast furnaces in the United States at the close of each year since 1912 is given in the following table:

BLAST FURNACES IN UNITED STATES

Fuel Used—Blast Furnaces.	1912.	1913.	1914.	1915.	1916.	1917.
Bituminous coal and coke	395	394	389	390	388	420
Anthracite, and anth. and coke	26	23	20	15	20	
Charcoal	45	45	42	40	40	35
Total	466	462	451	445	448	455

New blast furnaces completed in 1918 do not approach the remarkable record made in 1917. *The Iron Age*[1] gives a total of 8, as compared with 14 in 1917 and only 4 in 1916. The eight furnaces completed represent a capacity of 1,444,000 gross tons of pig iron. For 1919 there are seven blast furnaces under construction, most of which will probably be completed during the year. Four of these furnaces were listed as projected for completion in 1918, but are still uncompleted. The seven projected furnaces have an estimated capacity of 1,260,000 tons of pig iron per year. The following table gives details of new blast furnaces completed in 1918 and at present under construction.

[1] Jan. 2, 1919.

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Company.	Completed 1918.	Under Construction or Projected.
Brier Hill Steel Co	1	..
Lackawanna Steel Co	2	..
Alan Wood Iron & Steel Co	1	..
Bethlehem Steel Corporation:		
Steelton plant	1	1
Maryland plant	..	2
Henry Ford	..	2
Weirton Steel Co	..	1
Pittsburgh Crucible Steel Co	..	1
Steel Tube Co. of America:		
Iroquois Iron Co	1	..
Mark plant	1	..
U. S. Steel Corporation:		
Gary plant	1	..
Total	8	7

The four furnaces credited to the Gary plant of the United States Steel Corporation as projected in our review last year are not reported this year.

STEEL

The statistics of the output of steel in the United States for a number of years past are as follows:

PRODUCTION OF STEEL INGOTS AND CASTINGS FOR 14 YEARS
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Bessemer.		Open-hearth.		Crucible, etc.		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1905	10,941,375	54.6	1,155,648	5.8	111,196	0.6	12,208,219	61.0	7,815,728	39.0	20,023,947
1906	12,275,830	52.5	1,321,653	5.6	141,893	0.6	13,739,376	58.7	9,658,760	41.3	23,398,136
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,822	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,590	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874
1914	6,220,846	26.5	903,555	3.8	117,500	0.5	7,241,901	30.8	16,271,129	69.2	23,513,030
1915	8,287,213	25.8	1,370,377	4.3	184,721	0.6	9,842,311	30.6	22,308,725	69.4	32,151,036
1916	11,059,039	25.8	1,798,769	4.2	298,610	0.7	13,156,418	30.7	29,616,658	69.3	42,773,680
1917	10,479,960	23.2	2,061,386	4.6	431,754	1.0	12,972,605	28.8	32,087,507	71.2	45,060,607
1918	9,376,236	21.1	1,982,820	4.5	626,805	1.4	11,985,861	27.0	32,476,571	73.0	44,462,432

Included in the 32,476,571 tons of basic open-hearth steel ingots and castings produced in 1918 are 3,870,017 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 3,791,830 tons in 1917, an increase of 78,187 tons, or 2.1 per cent. In 1917 and 1918 duplex steel was produced by 10 works in 6 states, against 9 works in 5 states in 1916, 6 works in 4 states in 1915, 5 works in 4 states in 1914 and 9 works in 5 states in 1913.

Rails.—The total production of steel rails in the United States in 1918 was 2,540,982 gross tons, against 2,944,161 tons in 1917, a decrease of

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13.69 per cent. Below is given the record of rail production for the period 1909 to 1918, according to process of manufacture:[1]

PRODUCTION OF ALL KINDS OF RAILS IN GROSS TONS

Years, Rails.	Open-hearth Steel.	Bessemer Steel.	Re-rolled Steel.*	Electric Steel.	Iron.	Total.
1909	1,256,674	1,767,171	.....	†	.....	3,023,845
1910	1,751,359	1,884,442	.....	†	230	3,636,031
1911	1,676,923	1,053,420	91,751	462	234	2,822,790
1912	2,105,144	1,099,926	119,390	3,455	.....	3,327,915
1913	2,527,710	817,591	155,043	2,436	.....	3,502,780
1914	1,525,851	323,897	95,169	178	....	1,945,095
1915	1,775,168	326,952	102,083	.....	.....	2,204,203
1916	2,269,600	440,092	144,826	.....	.....	2,854,518
1917	2,292,197	533,325	118,639	.....	.....	2,944,161
1918	1,945,533	494,193	101,256	.....	.....	2,540,982

* Re-rolled from old steel rails and renewed rails which the manufacturers could not classify as Bessemer or open-hearth. Included with Bessemer and open-hearth steel rails to 1910. † Small tonnages rolled 1909 and 1910, but included with Bessemer and open-hearth rails for these years.

Girder and high T-rails for electric and street railways are included in the figures given above. For recent years the tonnage was as follows: 1912, 174,004; 1913, 195,659; 1914, 136,889; 1915, 133,965; 1916, 127,410; 1917, 91,674; 1918, 20,834 gross tons.

The total production of rails as given above includes, in addition to new rails rolled during the year, rails re-rolled from defective rails and from old rails. The total of renewed or re-rolled rails so included is given in gross tons in the following table.

PRODUCTION OF RENEWED AND RE-ROLLED RAILS, 1913–1918

Years.	Re-rolled from New Seconds, New Defective Rails, etc.			Rolled from Old Rails.	Total Re-rolled.
	Open-hearth.	Bessemer.	Total.		
1913	13,052	30,741	43,793	155,043	198,836
1914	13,538	13,234	26,772	95,169	121,941
1915	6,477	2,652	9,129	102,083	111,212
1916	1,711	2,149	3,860	144,826	148,686
1917	1,825	7,182	9,007	118,639	127,646
1918	13,296	19,462	32,758	101,256	134,014

WEIGHT OF ALL KINDS OF RAILS

Years— Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Less than 100.	100 Lb. and Over.	Total Gross Tons.
1909	255,726	1,024,856	1,743,263		3,023,845
1910	260,709	1,275,339	2,099,983		3,636,031
1911	218,758	1,067,696	1,536,336		2,822,790
1912	248,672	1,118,592	1,960,651		3,327,915
1913	*270,405	†967,313	2,265,062		3,502,780
1914	*238,423	†309,865	868,104	528,703	1,945,095
1915	*254,102	†518,291	742,816	688,995	2,204,203
1916	*295,535	†566,791	1,225,341	766,851	2,854,518
1917	*308,258	†882,673	989.704	763,526	2,944,161
1918	*387,907	†615,165	888,141	592,462	2,533,675

* Includes rails under 50 lb. † Includes 50 lb. and less than 85 lb.

[1] *Bull.* 2 (1919), Amer. Iron and Steel Inst.

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Included above is the annual production of alloy-treated rails, shown separately in the following tables. The tonnage of rails so treated was first determined in 1909.

PRODUCTION OF ALLOY-TREATED STEEL RAILS, 1909–1918

Years.	Total Production, Gross Tons.	Production by Alloys.		Production by Processes.	
		Titanium.	Other Alloys.	Open-hearth and Electric.	Bessemer.
1909	49,395	35,945	13,450	13,696	35,699
1910	257,324	256,759	565	13,696	229,935
1911	153,989	152,990	999	27,389	115,450
1912	149,267	141,773	7,494	38,539	108,874
1913	59,519	47,655	11,864	40,393	25,952
1914	27,937	23,321	4,616	33,567	490
1915	24,970	21,191	3,779	27,447	603
1916	28,562	26,493	2,069	24,367	887
1917	16,535	15,273	1,262	27,675	*Nil.*
1918	3,111	2,891	220	3,111	*Nil.*

Rolled Iron and Steel.—In 1918, the production of all kinds of iron and steel rolled into finished forms (including blooms, billets, and axle blanks rolled for forging purposes and semi-finished products which were rolled for export in that year) shows a decrease of 1,911,946 tons, or 5.8 per cent., as compared with the output in 1917.

TOTAL PRODUCTION OF ALL KINDS OF FINISHED ROLLED IRON AND STEEL, 1909–1918

Years.	Iron and Steel Rails.	Plates and Sheets.	Nail Plate.	Wire Rods.	Structural Shapes.	All Other Finished Rolled Products.	Total, Gross Tons.
1909	3,023,845	4,234,346	63,746	2,335,685	2,275,562	7,711,506	19,644,690
1910	3,636,031	4,955,484	45,294	2,241,830	2,266,890	8,475,750	21,621,279
1911	2,822,790	4,488,049	48,522	2,450,453	1,912,387	7,316,990	19,039,171
1912	3,327,915	5,875,080	45,331	2,653,553	2,846,487	9,908,475	24,656,841
1913	3,502,780	5,751,037	37,503	2,464,807	3,004,972	10,030,144	24,791,243
1914	1,945,095	4,719,246	38,573	2,431,714	2,031,124	7,204,444	18,370,196
1915	2,204,203	6,077,694	31,929	3,095,907	2,437,003	10,546,188	24,392,924
1916	2,854,518	7,453,980	30,088	3,518,746	3,029,964	15,493,093	32,380,389
1917	2,944,161	8,267,616	22,864	3,137,138	3,110,000	15,585,921	33,067,700
1918	2,540,892	8,799,135	18,310	2,562,390	2,849,989	14,385,058	31,155,754

Rolled blooms and billets for forging purposes are included above, while semi-finished products rolled for export are included for 1912 and subsequent years.

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PRODUCTION OF THE U. S. STEEL CORPORATION
Including Tennessee C., I., & Ry. Company

	1913.	1914.	1915.	1916.	1917.	1918.
Iron Ore Mined—	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
From Marquette Range	583,266	496,896	618,108	647,132	491,760	338,344
From Menominee Range	980,346	874,909	939,304	996,983	1,120,382	1,172,319
From Gogebic Range	1,871,700	1,469,601	1,277,419	2,369,460	2,197,554	1,916,220
From Vermillion Range	1,301,163	1,112,854	1,273,825	1,314,002	1,039,807	808,994
From Mesabi Range	21,634,206	10,894,463	17,209,664	24,928,039	23,806,268	21,574,526
In Southern Region	2,367,770	2,186,258	2,351,356	3,099,553	3,125,998	2,522,536
Total	28,738,451	17,034,981	23,669,676	33,355,169	31,781,769	28,332,939
Coke Manufactured	16,663,480	11,163,914	14,500,818	18,901,962	17,461,675	17,757,636
Coal Mined, not used in making coke	6,705,381	5,271,911	5,828,278	6,162,340	6,942,298	6,354,980
Limestone Quarried	6,338,509	4,676,479	5,795,925	7,023,474	6,494,917	5,141,365
Blast Furnace Products—						
Pig iron	13,879,706	9,909,062	13,517,598	17,412,049	15,460,638	15,700,561
Spiegel	65,236	25,397	7,175	31,486	} 192,290	240,393
Ferromanganese and ferrosilicon	135,788	117,578	116,735	164,102		
Total	14,080,730	10,052,457	13,641,508	17,607,637	15,652,928	15,940,954
Steel Ingot Production—						
Bessemer ingots	6,131,809	4,151,510	5,584,198	7,273,766	6,405,390	5,630,246
Open-hearth ingots	10,524,552	7,674,966	10,792,294	13,636,823	13,879,671	13,953,247
Total	16,656,361	11,826,476	16,376,492	20,910,589	20,285,061	19,583,493
Rolled and Other Finished Products for Sale—						
Steel rails	1,927,745	979,907	1,129,832	1,533,681	1,594,196	1,471,508
Blooms, Billets, Slabs, Tinplate Bars	1,108,147	921,826	1,404,443	1,881,526	1,692,348	1,489,737
Plates	.....	689,241	974,741	1,332,262	1,473,625	2,171,362
Heavy Structural Shapes	998,624	613,739	726,082	1,029,682	1,004,537	1,079,601
Merchant Steel, Skelp, Hoops, Bands	2,024,192	1,423,740	2,118,366	2,715,277	2,650,970	2,159,279
Tubing and Pipe	1,186,740	818,435	919,280	1,338,892	1,234,129	1,190,594
Rods	174,478	164,153	261,036	278,197	267,071	209,350
Wire and Products of Wire	1,432,182	1,380,376	1,771,945	2,004,494	1,821,985	1,445,567
Sheets—Black, Galvanized and Tinplate	1,280,537	1,075,419	1,368,178	1,786,642	1,740,949	1,356,119
Finished Structural Work	652,363	521,225	476,896	557,953	550,744	503,380
Angle and Splice Bars and Joints	256,676	129,849	190,758	277,271	207,846	145,305
Spikes, Bolts, Nuts and Rivets	86,465	62,133	74,289	95,096	91,980	67,514
Axles	159,075	64,662	95,476	173,530	220,291	141,480
Sundry Iron and Steel Products	245,439	117,159	251,317	456,289	392,240	418,687
Total	11,532,663	9,014,512	11,762,639	15,460,792	14,942,911	13,849,483
Spelter	30,424	28,031	32,031	55,898	67,418	41,715
Copperas (Sulphate of Iron)	33,829	30,212	35,377	46,263	43,942	42,321
Universal Portland Cement (Bbl.)	11,197,000	9,116,000	7,648,658	10,425,600	10,917,000	7,287,000

Electric Steel

The electric steel industry of the United States did not expand in 1918 to the remarkable extent which it did in 1917, so far at least as number of new furnace installations is concerned.[1] The growth, however, was of decided and significant proportions.

Statistics of the 1917 steel production, as collected by the American Iron and Steel Institute and not made public until early in 1919, show that the total output of electric steel ingots and castings was not far from double that of 1916, or 304,543 gross tons in 1917 as compared with 168,543 tons in 1916. It was more than ten times the 1913 production of 30,180 tons. About 79 per cent. of the 1917 total, or 239,632 tons, covered electric ingots, and this was double the corresponding out-

[1] *Iron Age*, Jan. 2, 1919.

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put in 1916. The increase in electric steel castings was not so large, having been a little more than 50 per cent. greater in 1917 than in 1916, or 64,911 tons as against 42,870 tons. The ingot output was about twelve times and the steel casting about six times that made in electric furnaces in 1913. The data also show that the electric furnace has replaced the crucible so far as new installations are concerned, the 1917 crucible output having been less than in 1916.

A prominent feature of the 1917 output was that of alloy steels made in electric furnaces. Nearly 50 per cent. of the total electric ingot production was alloy steels, or 129,282 tons, a surprising revelation. The large war demand in that year for automobile, and later in the year for ordnance ingots explains this striking fact. Less than 2 per cent., or 1296 tons, of the electric-steel casting output was alloy castings.

The electric steel production in 1918 was 511,364 tons, an increase of nearly 70 per cent. over 1917, of which 287,885 tons was alloy steel ingots and 3076 tons alloy steel castings.

The production of electric steel in the United States is as follows:

1909	13,762
1910	52,141
1911	29,105
1912	18,309
1913	30,180
1914	24,009
1915	69,412
1916	168,918
1917	304,543
1918	511,364

On Jan. 1, 1918, the United States was credited with 233 electric furnaces of all types, with 36 in Canada. On Jan. 1, 1919, this total had been increased to 287 in this country and 43 in Canada. Only five and one-half years ago, or on July 1, 1913, there were only 19 such furnaces in this country and three in Canada. The total in the world on Jan. 1, 1918, was estimated at 733; this has been increased to over 815 and perhaps more. Five and one-half years ago this total was only 140.

Progress in the United States and Canada in 1918.—The increase in the number of furnaces in the United States in 1918 was 54 against 97 in 1917 and 63 in 1916. The total is now 287 against 233 on Jan. 1, 1918, and 136 on Jan. 1, 1917. The apparent net increase of 54 in the last year is less than the actual, due to cancellation of contracts or the passing out of commission of some installations. The growth of the industry is appreciated when it is recalled that there were only 19 furnaces of all types in the United States on July 1, 1913.

In Canada the expansion has been a net increase of 7 furnaces, or from 36 on Jan. 1, 1918, to 43 on Jan. 1, 1919. The actual new installations were more numerous. On Jan. 1, 1917, there were only 19 furnaces in Canada and only 3 on July 1, 1913.

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The increase in the two countries has been 61 furnaces in 1918, or from 269 on Jan. 1, 1918, to 330 on Jan. 1, 1919.

The feature of the development in 1917 in both the United States and Canada was the large number of companies which expanded their original installations into larger plants or which made larger installations. While there have been no such striking developments in 1918, most of these companies and some others have either maintained their output or in some cases slightly increased it by the installation of a new furnace or the substitution of a larger unit for a smaller one.

The table of Heroult furnaces this year gives all those that are now in existence or licensed to operate up to Jan. 1, 1919. Previous to this only those licensed or operating in any one year were included in the table of the review. The total of this type on Jan. 1, 1919, was 145 in the United States and 18 in Canada, or 163 in both countries as contrasted with 146 in the United States and Canada on Jan. 1, 1918. The actual number of furnaces licensed in 1918 was 22 as against 62 in 1917. The expansion in 1917 was abnormal and due to war conditions, while that for 1918 was probably more normal. The 1918 total would have been larger, however, had not the signing of the armistice changed the plans of some producers. This is true of other types of furnaces as well. The Heroult furnace continues to maintain its leadership in installations and output. The installations in the United States exceed that of its nearest competitor by 100, the Snyder being credited with 45.

The Snyder furnace expanded its representation quite decidedly in 1918. It is now credited with 45 in the United States and 3 in Canada as against 32 in the United States and 3 in Canada in 1917. On Jan. 1, 1917, there were only 22 Snyder furnaces in the two countries. The growth since then has therefore been 100 per cent. in three years.

It is interesting to note the increase in the installations of some of the newer types. In 1918 the Ludlum has increased its installations from 6 to 11, the Booth-Hall from 4 to 11, the Moore from 4 to 12 and the Greene from 1 to 8. The status of the Rennerfelt, the Greaves-Etchells, the Grönwall-Dixon, the Girod and the Webb has changed but little in the aggregate number of installations.

A newcomer in the field in 1918 was the Vom Baur furnace, which is credited with two installations in the United States and three in Japan. The Wile furnace has disappeared altogether so far as can be ascertained, and there is only one Stassano furnace now in existence in either the United States or Canada.

As to furnaces classed as special, very little can be said. The total in the year shows a net gain of 3, or from 24 to 27, in both the United States and Canada. Of these 21 are in Canada, many of them said to be

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similar to certain types in this country. Some of them are making low-phosphorus pig iron from scrap steel.

The induction, as contrasted with the arc furnace, still remains in the background. There has been absolutely no development in this type of furnace in the last year nor in the last few years. The arc furnace continues to be the popular medium of transmitting the electrical heat to the material to be melted and refined, whether it is three-phase, two-phase or single-phase.

One of the tables gives the number of furnaces of each type in the United States and Canada on Jan. 1, 1919, with the total a year ago and two years ago. In the last two years, or since Jan. 1, 1917, the total number of furnaces in the two countries has more than doubled, or from 155 to 330. The total was only 81 on Jan. 1, 1916, and 19 on July 1, 1913.

Owing to world-war conditions it has been impossible this year to even estimate the status of the electric steel industry in countries outside the United States and Canada. The table, however, which was published a year ago is reproduced as a matter of record, leaving the column for furnaces in foreign countries practically blank, except in a few cases where certain new installations have been announced, principally sales by American furnace makers. Adding those to the total in the world on Jan. 1, 1918, brings the total on Jan. 1, 1919, to not less than 815, assuming estimates a year ago to have been fairly accurate.

ELECTRIC STEEL FURNACES BY COUNTRIES OF THE WORLD OPERATING OR CONTRACTED FOR ON JAN. 1, 1919, WITH TOTALS FOR 1918, 1917, 1916, 1915, 1913 AND 1910

	Total Jan. 1, 1919.	Total Jan. 1, 1918.*	Total Jan. 1, 1917.	Total Jan. 1, 1916.	Total Jan. 1, 1915.	Total July 1, 1913.	Total March, 1910.
Germany and Luxemburg	.....	91	52	53	46	34	30
Austria-Hungary	.....	31	18	18	18	10	10
Switzerland	.....	4	4	4	3	2	2
Italy	.....	40	29	22	22	20	12
France	.....	50	29	21	17	13	23
Great Britain	.....	131	88	46	16	16	7
Belgium	.....	.....	3	3	3	3	3
Russia	.....	21	16	11	9	4	2
Sweden	.....	50	40	23	18	6	5
Norway	.....	12	9	6	2	3	.....
Spain	.....	2	2	2	1	1	.....
Japan	11	4	2	1	1	1	.....
South Africa	.....	2	1	1	1	4	3
Australia	2	1	1	1	1	.....	.....
Chile	3	2	.....	1	.....	.....	.....
Denmark	.....	2	1	.....	.....	.....	.....
Brasil	2	.....	.....	.....	.....	.....	.....
India	1	.....	.....	.....	.....	.....	.....
Location not given	.....	21	21	9	12	.....	.....
Total outside U. S. and Canada	.....	464	316	222	170	118	101
United States	287	233	136	73	41	19	10
Canada	43	36	19	8	2	3	3
Total in U. S. and Canada	330	269	155	81	43	22	13
Grand total in the world	815†	733	471	303	213	140	114

*Largely estimated. † Known new installations added to 1918 total.

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It is probable that the greatest expansion in 1918, outside of the United States, has been in England, the same as took place in 1917. Later reports show that the number of furnaces on Jan. 1, 1918, was 140 instead of 131. Of these over 50 are Heroult furnaces, with the Greaves-Etchells, Electro-Metals, Rennerfelt, Snyder, Stassano, Stobie following in the order named.

NUMBER OF ELECTRIC FURNACES IN UNITED STATES AND CANADA

	In the U. S. Jan. 1, 1919.		In Canada Jan. 1, 1919.		Total in U. S. and Canada Jan. 1, 1919.	Total in U. S. and Canada Jan. 1, 1918.	Total in U. S. and Canada Jan. 1, 1917.
Heroult	145		18		163	146	84
Snyder	45		3		48	35	22
Rennerfelt	13		.....		13	13	13
Greaves-Etchells	11		.....		11	12	.....
Grönwall-Dixon	12		1		13	12	9
Ludlum	11		.....		11	6	5
Girod	5		.....		5	5	4
Booth-Hall	11		.....		11	4	.....
Moore	12		.....		12	4	.....
Induction	3		.....		3	3	3
Webb	2		.....		2	2	.....
Stassano	1		.....		1	1	1
Vom Baur	2		.....		2	.....	.....
Greene	8		.....		8	1	1
Special	6		21		27	25	13
Total	287	+	43	=	330	269	155

It is also likely that the use of the electric furnace in Germany has greatly expanded for war purposes, particularly for making gun steel and other important war material formerly believed possible only from open-hearth or Bessemer steel.

World Output of Electric Steel.[1]—The United States not only leads the world in the output of electric steel, but its total is not far from equal to that of all the other principal countries combined. In 1917 this country made 304,542 gross tons of electric steel. Germany in the same year made 219,700 metric tons; Great Britain's total was 68,849 gross tons. The French output has not been made public, but that of Canada was 39,069 tons in 1917 and that of Sweden 10,664 tons, both doubling their 1916 production, as did also the United States. Corresponding progress, however, is not shown by the German and British statistics. The German 1917 output of electric steel was only about 20,000 tons over that of 1916 and a similar gain was made in Great Britain.

It is probable that the figures for 1918 will show much greater strides. In the United States the production in 1918 almost doubled the 1917 figures. It is also evident that the 1918 output in Great Britain was nearly twice that of 1917, for it is stated that for the twelve months

[1] *Iron Age*, April 3, 1919.

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ended Sept. 30, 1918, the total had reached 110,000 tons, of which one company had made 31,850 tons, with the country's electric steel capacity now rated at 150,000 tons per year. Canada's 1918 output is estimated at 120,000 tons, an increase over 1917 of about 300 per cent. The German output was nearly stationary in 1918, at 221,824 tons.

It is certain, therefore, that the United States will maintain its supremacy in this department and that Great Britain will soon drive Germany from second place, which she has held since 1915 when the United States took first rank.

Foreign Countries

World's Iron-Ore Reserves[1]

The iron-ore resources of the world in relation to national economic conditions after the war were discussed by the New York Section of the American Institute of Mining Engineers in May, 1918. J. E. Johnson, Jr., the chairman, in introducing the subject, emphasized its importance with reference to the final peace conference and the future peace of the world. E. C. Harder, of the U. S. Geological Survey, read a short paper on the iron-ore deposits of Brazil. He drew attention to the fact that before the war capital was becoming interested in the Brazilian deposits, which consist of five great fields, the largest containing probably 500,000,000 tons. He believed that they will play an important rôle in the world's steel industry, despite their unfavorable location. It does not seem likely that they can be smelted in Brazil because of the dearth of coal. Most of the probable output of 10,000,000 tons per year will go to England, because the ores are suited to the British acid Bessemer process, but some will make up for the United States the decrease in domestic Bessemer ores.

Prof. W. Lindgren, of the Massachusetts Institute of Technology, discussed the deposits of Scandinavia. The Swedish ores have long been known for their high quality. They consist of three groups, the southern being the best known, but having small reserves. The second group is that of central Sweden, which to the world as a whole is of no particular interest. The important group is that of Lapland in northern Sweden, with an ore reserve of some 1,200,000,000 tons, and in which are the famous Kiruna mines, credited with 760,000,000 tons, all high in phosphorus. Sweden's production of iron ore is about 6,000,000 to 7,000,000 tons per year, of which normally about two-thirds goes to Germany and one-third to England. Norway's prospective supply is about 218,000,000 tons.

[1] *Iron Age*, May 30, 1918. "Notes on Certain Iron-ore Resources of the World." *Bull. Am. Inst. Min. Eng.*, 141, 1471 (1918); *Trans.*, 61.

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The Cuban situation was thoroughly dealt with by C. M. Weld, who placed that country's iron-ore reserves at 3,000,000,000 tons. The deposits being a soft, wet ore, the actual yield of these reserves will not be more than one-third or 1,000,000,000 tons. The speaker discussed the three important districts and the character of the deposits. Only one has been thus far actively worked, the Mayari. The Moa field is divided principally as follows: Bethlehem Steel Co., 78,500 acres containing 1,170,000,000 tons of ore; Midvale Steel Co., 19,840 acres with 300,000,000 tons; United States Steel Corporation, 15,000 acres with 210,000,000 tons; Eastern Steel Co., 50,000,000 tons; others, 155,000,000 tons, making a grand total of 1,985,000,000 tons. Mr. Weld stated that while the extensive nodulizing kilns are doing satisfactory work, experiments are being made with standard sintering processes which might prove better. The nodules analyze on the average 55 per cent. of iron, 4.50 per cent. silica, 13 per cent. alumina, 1 per cent. nickel and 1½ per cent. chrome. The nodulizing capacity is 500,000 tons per year, and before the war the freight charge to the United States was 85 cts. per ton. He discussed the metallurgical features of the ore with its alloy content, and believed the future of this phase of the subject very important.

THE GREAT IRON DEPOSITS OF THE WORLD[1]

Location of District.	Millions of Tons.	Average Grade of Ore, Per Cent. Iron.	Assumed Cost of Mining, etc.	Freights.		Cost to Furnace per Unit of Iron.	
				To Atlantic Coast.	To Valley Points (Note *a*).	Atlantic Coast.	Valley.
Brasil	5,000	68	$1.00	$4.00	$5.60	$0.073	$0.097
Newfoundland	3,500	50	1.25	1.25	2.85	0.050	0.082
Lake Superior	2,750	52	3.15	1.70	0.70	0.093	0.074
Sweden	2,200	57	2.00	2.00	3.60	0.071	0.095
Northern Cuba	3,000(*b*)	36	2.00	0.90	2.50	0.058	0.090
New York and New Jersey	2,500(*b*)	35	2.50	1.00	2.60	0.061	0.089
Alabama	1,750(*c*)	36	1.00	0.25	2.75	0.035	0.105
Norway	500(*b*)	35	2.50	2.00	3.60	0.075	0.102

Under head of "Assumed Costs of Mining, etc.," figures are in part necessarily assumed, as in Brasil. For Newfoundland they are based on results. For Lake Superior the $3.15 average is because 50 per cent. of Lake ore has averaged $2.90 in cost at Lake Erie for past 6 years, and knowing that this 50 per cent. has lesser royalties and greater steam-shovel proportion than on the remainder, it is assumed the remainder costs 50 cts. more per ton, giving the $3.15 average.

(*a*) Freight and dock charges to Valley points from seaboard are assumed at $1.60. There is no rate, but the assumption is based on a set of some 25 rail rates covering iron-ore movement in the United States.

(*b*) The cost of ore to furnace is figured, not against crude analyses, but against an average iron content in concentrate produced.

(*c*) Alabama ores are smelted at the furnaces, and the figure of 25 cts. in column of "Freights to Atlantic Coast" is merely the switching and delivery charge from mine to furnace. To this should be added freight on product to the sea, to complete this comparison.

All the above figures are based on fairly normal conditions, both as to freights and mining costs, and are not to be considered as representing present conditions, except for tonnages and grades. It is exceedingly difficult to give a figure on freights from Brasil, as no iron ore has yet been shipped from that country. The figures given for other points represent perhaps subnormal conditions in the ocean tonnage markets, but they are figures that are likely to return in the course of a few years.

[1] *Iron Age*, Apr. 24, 1919.

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A. C. Spencer, of the U. S. Geological Survey, discussed the deposits of southern Europe and the Mediterranean, while Dr. H. F. Bain, of the U. S. Bureau of Mines, who had recently returned from China, gave an interesting description of China's much-discussed and more or less overrated iron-ore resources. China's reserves he classed as of moderate value and similar in character to those of Spain. The total he placed at about 400,000,000 tons.

World's Production

The world's production of iron and steel, so far as data are available, is noted in the accompanying tables:

PIG-IRON PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1908	1,650,000	1,206,440	572,284	3,391,150	11,813,511	112,924	.....
1909	1,958,786	1,632,350	686,886	3,632,105	12,917,653	207,800	.....
1910	2,010,000	1,852,090	726,471	4,032,459	14,793,325	215,000	.....
1911	2,095,000	2,046,280	832,376	4,426,469	15,280,527	302,931	53,065
1912	2,312,689	2,301,290	920,636	4,871,992	17,852,571	379,987	56,341
1913	2,369,864	2,484,690	1,024,424	5,311,316	19,291,920	426,775	56,663
1914	2,020,000	1,454,400	710,481	5,025,000	14,389,547	385,114	74,055
1915	1,960,000	68,150	828,920	4,750,000	11,790,199	377,510	64,984
1916	2,418,322	127,825	1,060,787	1,447,000	13,314,238	467,005	77,283
1917	.....	7,990	1,063,084	1,684,000	13,142,247	471,180	.....
1918	.....	.....	1,077,160	1,297,000	11,754,542	.....	.....

Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All other Countries.	Total.
1908	2,748,000	403,500	563,300	9,438,477	16,190,994	550,000	48,640,419
1909	2,871,332	389,000	443,000	9,818,916	26,108,199	550,000	61,217,064
1910	3,042,046	367,000	604,300	10,380,723	27,636,687	525,000	66,210,720
1911	3,521,000	408,667	633,800	9,718,638	34,027,940	485,000	73,831,693
1912	4,197,638	403,243	701,900	8,751,464	30,202,568	485,000	73,443,043
1913	4,548,376	424,773	735,000	10,481,917	31,482,406	495,000	79,133,124
1914	4,261,008	425,000	635,100	9,005,898	23,721,115	420,000	62,536,718
1915	3,696,580	439,835	767,600	8,793,659	30,414,817	415,000	64,367,234
1916	3,737,593	497,726	737,300	9,193,656	40,092,043	425,000	73,595,778
1917	3,000,000	357,699	821,200	9,572,190	39,243,018	.....	.....
1918	.....	.....	749,800	9,184,974	39,677,728	.....	.....

STEEL PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1908	2,025,182	1,065,500	534,631	2,727,717	10,480,349	537,000	.....
1909	1,969,538	1,370,000	684,677	3,034,571	12,049,834	661,600	.....
1910	2,188,371	1,449,500	745,971	3,506,497	13,698,638	635,000	.....
1911	2,363,006	2,192,680	800,504	3,680,613	15,019,333	736,000	10,222
1912	2,785,105	2,515,040	868,811	4,078,352	17,301,998	801,951	12,451
1913	2,682,619	2,466,630	1,060,503	4,419,241	18,958,819	846,085	13,728
1914	2,190,759	1,396,300	751,738	.....	15,619,719	796,152	15,386
1915	2,686,226	98,820	926,157	.....	13,237,646	1,009,240	16 766
1916	3,340,000	99,371	1,295,707	1,952,000	16,182,520	1,269,486	23,861
1917	2,920,000	9,530	1,583,786	2,232,000	16,587,360	1,331,641	.....
1918	.....	.....	1,717,390	1,912,000	13,756,813	.....	.....

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Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1908.	2,628,000	301,360	427,100	5,380,912	14,247,619	300,000	44,359,522
1909.....	3,071,000	309,479	310,600	5,976,322	24,338,302	325,000	53,499,974
1910.....	3,479,000	316,301	468,600	6,477,110	26,512,437	315,000	58,656,312
1911.....	3,870,000	322,981	456,500	6,565,645	24,054,918	315,000	60,387,354
1912.....	4,498,000	317,880	508,300	6,904,546	31,751,324	325,000	72,668,758
1913.....	4,827,000	365,118	582,700	7,787,264	31,822,555	325,000	76,157,262
1914.....	4,732,000	382,044	500,600	7,918,243	23,904,914	300,000	.....
1915.....	4,900,000	387,314	588,800	8,687,670	32,686,887	300,000	.....
1916.....	4,696,000	322,931	717,600	9,344,520	43,462,336	320,000	83,026,332
1917.....	.....	470,241	681,700	9,909,338	45,786,083	.....	.....
1918.....	.....	.....	.....	.....	45,178,307	.....	.....

Algeria.[1]—The shipments of iron ores from Algiers aggregated 782,047 metric tons in 1918, as against 1,065,512 tons in 1917 and 938,684 tons in 1916. The declared value of the ore shipped in 1918 was about 13s. per metric ton at the port of embarkation. Of the 1918 shipments 7400 tons found their way to France; the rest is stated to have been shipped to the United Kingdom.

Australia.—The production of iron and steel from 1913 to 1917 was as follows, in gross tons:

Year.	Pig Iron.	Steel Ingots.	Steel Castings.
1913.....	46,563	.....	.....
1914.....	75,150	24,420	.....
1915.....	76,318	62,351	.....
1916.....	126,591	108,409	.....
1917.....	146,419	155,000(a)	631

(a) Partly estimated.

The Commonwealth Steel Products Co., recently organized, has begun construction of a plant at Waratah, a short distance from the Newcastle steel works. An innovation in this section will be the installation of a 6-ton electric furnace, the raw material for which will be scrap iron and steel. This furnace will produce the steel for casting car-wheel centers and locomotive parts, and also ingots from which tires will be forged and rolled. The works will occupy about 47 acres, containing railroad sidings for the expeditious shipment of material. The forging plant will contain the necessary reheating furnaces, three large forging hammers, and a tire-rolling mill. It is stated that this will be the first mill in Australia to roll tires. All of the tools for machining and finishing will be of the most modern type. The company will manufacture a portion of the steel for its requirements, but will purchase blooms and ingots from other plants.[2]

The Australian Electric Steel Co., Ltd., at Sidney, has two electric furnaces of 2 tons capacity each.

The Australian Government[3] has decided to acquire for £3000

[1] *Echo des Mines.*
[2] *Iron Age*, Jan. 9, 1919.
[3] *Comm. Rept.*, Sept. 28, 1918.

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an option for 12 months on the properties and rights of the Blythe River Iron Mines, Ltd., Tasmania. The Government geologist of Tasmania stated in 1903 that the Blythe River ore was of a very desirable purity and was sufficient to supply the requirements of the iron manufacturers for many years. It was estimated that from the water level upward the deposit contained 17,000,000 to 23,000,000 tons of marketable ore. Further testimonies to the high quality of the ore have also been made from time to time, it having been stated to be, according to the analysis of the Tasmanian Government analyst in 1904, one of the finest and purest in the world.

The Queensland Government[1] geologist has been carrying on investigations that have resulted in the discovery of a large quantity of iron ore about 14 miles from Warwick. Tests show the ore to contain 66 per cent. of iron, which is the same percentage as that smelted at Newcastle. The Government will conduct its first smelting operations at Ipswich, where 50 tons of Biggenden ore will be treated.

Austria-Hungary.—The steel ingot output of Austria-Hungary during the war is now made public by data in *Stahl und Eisen.* The production by grades was as follows in 1915, 1916 and 1917, in metric tons:

	1915.	1916.	1917.
Acid Bessemer	645	1,044	578
Basic Bessemer	241,045	342,670	335,904
Open-hearth	2,370,947	2,893,409	2,498,954
Puddled iron and steel	23,543	18,204	13,296
Crucible	26,151	34,033	31,905
Electric	23,895	47,247	47,152
Total	2,686,226	3,336,607	2,927,789

Austria is credited with 2,501,070 tons and 2,211,139 tons respectively of the 1916 and 1917 output. Austria also made 45,811 tons of the 1916 electric-steel output and 44,587 tons of the 1917 electric production.

The following table shows the deliveries of some of the iron and steel products in Austria during 1916 and 1917, in metric tons:[2]

	1916.	1917.
Foundry pig iorn	77,004	56,735
Cast-iron pipes	32,176	26,962
Semi-product	356,207	380,783
Bars and shapes	622,062	561,418
Joists and channels	96,143	64,936
Plates	89,969	64,116
Sheets	137,466	93,589
Rails and fastenings	119,098	89,838
Axles	1,904	2,154
Tires	10,086	11,264
Wheels and wheel sets	39,226	33,100
Steel castings	41,034	36,506

These figures are for Austria alone, without Hungary.

According to the *Neue Freie Presse* (Dec. 15, 1918), the Prague Iron Co. announced that between July and October the profits of the industry

[1] *Comm. Rept.*, May 27, 1918.
[2] *Iron & Coal Tr. Rev.*, Mar. 14, 1919.

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diminished by 2,000,000 kroner. The sales, which had already been reduced in 1917, declined still further. During the war the industry had made very large profits, and there were hopes that the boom would continue after the conclusion of peace, but no new orders were coming in.

Several Czech wholesale iron dealers of Prague and the provinces are negotiating for the foundation of an iron-trading company, with a capital of 10,000,000 kroner. The company, which is to be established on a democratic basis, is negotiating for the taking over of the largest iron firms in Prague.[1]

Belgium.—Not until early in 1919 was data made public regarding the iron and steel output of Belgium, nor definite information as to the condition of Belgian iron and steel plants.

The report compiled by M. Dejardin, Director General of Mines, gives the following data on the output in 1914, 1915 and 1916:

	1914.	1915.	1916.
Number of iron and steel plants at work	19	4	4
Number of furnaces in blast	54	6	6
Number of days in blast	207	175	222

The output of iron and steel was as follows, in metric tons:

Pig Iron:	1914.	1915.	1916.
Foundry iron	60,310	26,260	58,805
Forge iron	28,660	3,150	17,040
Steel making (Bessemer)	44,390	14,730	17,400
Steel making (open-hearth)	1,316,450	19,780	36,540
Special pig iron	4,680	4,230	.....
Total	1,454,490	68,150	127,825
Direct castings	32,320	4,350	2,541
Bessemer steel	1,248,370	67,510	40,860
Open-hearth steel	111,610	26,960	55,970
Blooms and billets	845,670	40,140	34,780

Further data supplementing the above and including 1917 was published later.[1] In 1917 only one steel plant was operating and only one furnace in blast. The pig-iron output was only 2460 metric tons of Bessemer and 5530 tons of open-hearth iron. The following table gives the data from 1913 to 1917, in metric tons:

[1] *Iron Age*, May 1, 1919.

	Pig Iron.	Finished Steel.	Finished Iron.
1913	2,484,690	1,409,460	304,350
1914	1,454,490	866,350	151,110
1915	68,150	94,270	38,090
1916	127,825	61,900	101,300
1917	7,990	23,630	51,620

The production of steel rails fell from 341,870 tons in 1913 to 29,470 tons in 1915 and 730 tons in 1917, and of beams from 175,210 tons in 1913 to 5490 tons in 1915 and 60 tons in 1917. The merchant steel output is given as 518,370 tons in 1913, 36,680 tons in 1915, and 3950 in 1917.

[1] *Min. Jour.*, Mar. 10, 1919.

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Testimony as to the condition of Belgian blast furnaces and steel plants as a result of German devastation is contained in extracts from various foreign sources. Statements[1] as to the chief Belgian works are as follows:

Sambre et Moselle.—Three furnaces, which could all be put in blast in 3 months if material were available. The four Thomas converters remain in good order, but the Martin furnaces have been destroyed, and three of the ten rolling mills wiped out. The electrical and mechanical plant has been wrecked, all the copper and brass having disappeared. Further, nearly all the fixed material and rolling stock, including locomotives, trucks, machine tools, ingot moulds, etc., have been carried away. The damage is estimated at between 7 and 8 million francs.

Thy Le Chateau.—Four furnaces, all partly demolished. No estimate of period of restoration possible. The four Thomas converters have been dismantled, also six rolling mills. The damage is estimated at 20 million francs.

Moncheret.—One furnace, which was partly destroyed.

Sud de Chatelineau.—Two furnaces, both partly destroyed. Repairs proceeding. One expected to be restored by the end of June, 1919, and the other by September.

Hainaut.—Four furnaces, which, having been requisitioned by Germany, are intact. Only raw materials are required to make a fresh start. The steel equipment is also intact, including four converters, two Martin furnaces, and five rolling mills.

Bonehill.—Two furnaces, both demolished.

Monceau.—Three furnaces, all put out of gear.

Providence.—Five furnaces, all completely destroyed. From 6 months to a year necessary to get to work again. The four converters have been so badly damaged that a long time will be required to restore them, and of the nine rolling mills only four are capable of repair. At Marchiennes the central power station has been stripped bare of the copper, and the twelve steam boilers and the two blowing engines removed bodily or smashed, while at Dampremy the two blowing engines have been carried away, and also the gas-mains. From the coke works ten boilers have been removed. At the steel works, of the four converters, mixers, machinery, 22 boilers, and slag grinder, nothing is left but a motor from which essential parts have been removed. Nothing remains of the rolling mills at Marchiennes, which contained four blooming trains driven by machinery of 6000 to 10,000 hp. At Bellevue, however, the rolling mills can be started again when current is provided. The estimated damage exceeds 25 million francs.

Chatelineau.—Two furnaces, parts of which, including the tuyères, have been removed. Repairs will take 6 months. The three converters can be set going again possibly by July, but the two rolling mills can not be repaired so rapidly. The damage is estimated at from 1 to 2 million francs.

Clabecq.—Two furnaces, both incapable of work. The converters and six rolling mills have been demolished, and the damage is estimated at from 15 to 17 million francs.

G. Boël.—It is said that the Germans here excelled themselves in the task of destruction. Of the two blast furnaces, three steel converters, three Martin furnaces and ten rolling mills, nothing remains but heaps of scrap. The damage is estimated at beween 25 and 30 million francs.

Cockerill.—Seven furnaces. One could probably be started in 4 to 6 weeks, but

[1] *Metal Bull.*, Feb. 17, Mar. 10, Mar. 21, 1919.

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the others will require up to 6 months for repairs. Three of the five converters, four of the eight Martin furnaces, and eight of the twelve rolling mills have been destroyed.

Ougree-Marihaye.—Four furnaces destroyed and four standing. Four of the eight converters and nine of the twelve mills demolished.

Angleur.—Four furnaces, of which two can easily be repaired. Two of the four converters and six of the eight mills wrecked.

Esperance.—Three furnaces, all needing repairs which will take from 2 to 6 months. Two of the four converters and three of the four mills were distroyed.

Grivegnee.—One furnace, which was completely destroyed.

Halanzy.—Two furnaces, one of which can be repaired in a year.

Athus.—Three furnaces. All of the electrical plant, including the hoisting gear, destroyed.

Musson.—Two furnaces, both completely destroyed.

Brazil.—That the iron-mining industry in Brazil is to be developed soon seems very evident. This impetus is due to the fact that many important iron-ore deposits have been acquired by foreign and Brazilian syndicates.

There are given below[1] the names of the companies that are at present said to be the more important iron-property owners:

The Itabira Iron Ore Co., an English concern, with its head offices in London. This group has control of the Victoria Minas Railway. These deposits, situated at Itabira de Matto Dentro, are estimated at 99,000,000 cubic meters and capable of producing 296,000,000 tons.

The Brazilian Iron & Steel Co., an American corporation, has acquired also in Itabira de Matto Dentro two deposits containing 33,000,000 cubic meters or over, or 132,000,000 tons, and two deposits situated in the municipality of Santa Rita Durão (Marianna), reported to be capable of producing 10,000,000 tons. The same organization also has a concession to construct a railroad operating between the mines of Santa Rita Durão (Marianna) and S. José da Lagoa.

The Minas Geraes Iron Syndicate, an American company, has purchased the deposits of Paracatú and Bananal, situated in Cattas Atlas and in Santa Barbara.

The Société Franco-Brésilién ne and Bernard Goudchaux & Co. (presumably French), has acquired the deposits of Candonga, in S. Miguel de Guanhães, estimated as containing 10,000,000 tons of ore.

The Société Civile de Mines de Fer de Jangada, a French company, has purchased the Jangada mines, in the municipality of Villa Nova de Lima (Paraopeba), with a capacity of 15,000,000 tons.

The Deutsch Luxemburgischs Bergwerks und Hütten Aktiengesellschaft, a German company, purchased the Corrego do Feijão deposit, situated in Piedade do Paraopeba (Villa Nova de Lima).

A. Thum purchased the "Casa de Pedra" mine, situated in Congonhas (Ouro Preto), with 500,000 cubic meters, and capable of producing 2,000,000 tons.

The Bracuhy Falls Co., organized in this country, has purchased two mines situated in Congonhas (Ouro Preto), with deposits calculated at 8,000,000 cubic meters, and capable of producing 29,000,000 tons. The same company has also acquired a deposit situated in Paraopeba (Bomfim).

[1] *Comm. Rept.*, July 23, Aug. 10, Nov. 7, 1918.

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Mr. Carlos Wigg, of Rio de Janeiro, has purchased three deposits situated in Serra da Moeda (Ouro Preto), capable of producing 10,000,000 tons.

Trajano de Medeiros, a Brazilian engineer, has purchased three deposits situated in Serra da Moeda (Ouro Preto), capable of producing 12,000,000 tons.

The "Corrego do Meio" deposits, situated in Sabará, were acquired by a German syndicate.

The Companhia Metallurgica Brazileira, with head offices in Rio de Janeiro, which is also connected with the manganese mining interests, Companhia Morro da Mina, purchased eight mines, all located in the State of Minas Geraes, the group representing a total reserve of some 100,000,000 tons.

The Companhia de Mineração and Metallurgia do Brazil, organized on Sept. 8, 1917, in Rio de Janeiro, has acquired the iron mines belonging to Antonio da Costa Lage, who is one of the incorporators and the largest shareholder in this company.

The Canadian Metallurgic Co., which is said to be making plans for an electric smelting furnace on Governor's Island in the Bay of Rio de Janeiro, capable of producing 500 tons of steel daily, has acquired a manganese mine at S. João d'El Rey, and also certain iron deposits.

The Companhia Siderugica Mineira, with its head offices in Bello Horizonte, State of Minas Geraes, and founded in 1917 for the purpose of exploiting the iron industry has also acquired important deposits of iron, which are now being operated.

The firm of Queiroz Junior & Co., owners of the Usina Esperança (Esperança Mill) and concessionnaires of the Usina Wigg, also possess an extensive deposit of iron ore situated at Itabira de Campos, the ore being of excellent quality.

The Companhia Siderurgica Brazileira owns seven deposits of iron ore in the State of Minas Geraes, with a total area of 7120 hectares, which also contains considerable manganese ore.

Besides the deposits referred to above, it is said that negotiations are being carried on to obtain the deposits known as "Fabrica," situated in Congonhas de Campo (Ouro Preto), belonging to Col. Machado; also deposits known as "Tres Irmãos," situated in the municipality of Bomfim, and one known as "Serra do Pires," located in the municipality of Ouro Preto.

It is reported that the Itabira Iron Ore Co., which owns immense deposits in Itabira and Matto Dentro, with more than 100,000,000 tons of iron ore running from 68 to 70 per cent. in purity, will soon exploit these deposits. The plan is to construct a branch line of the Victoria & Minas Railway, which is under that company's control, to transport the ore to tidewater. The plans of this company are as follows: (*a*) To install modern machinery in the mines for the extraction of large quantities of ore; (*b*) to extend the railroad to the mines at Itabira de Matto Dentro; and (*c*) to construct a fleet of vessels specially built to discharge the mineral automatically at the destination in Europe and to be suitable for transporting coal from Europe to Brazil.

According to newspaper report, the British firm of Armstrong & Vickers has presented to the Brazilian Government important proposals for the exploitation of iron deposits, the manufacture of iron and steel products of all kinds, the erection of dry docks, and the development of related industries.

The "Companhia Siderurgica Mineira" (The Iron & Steel Mining Co.) will shortly complete its new establishment at Sabara, State of Minas Geraes, Brazil, which will be one of the most important of its kind in South America.

Canada.—The total shipments of iron ores from Canadian mines show a further falling off in 1918, being only 206,820 short tons valued

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at $863,186, or an average of $4.17 per ton, as compared with shipments in 1917 of 215,302 tons valued at $758,621, or an average of $3.52 per ton.[1] The 1918 shipments included 8153 tons from Quebec, 197,637 tons from mines in Ontario, and about 900 tons mined in British Columbia. The ores comprised 170,907 tons of hematite and roasted hematite and siderite, 28,559 tons of magnetite, 6324 tons of ilmenite and titaniferous ore, and 900 tons (dry) of bog ore.

The principal operations were as usual in Ontario at the Helen and Magpie mines of the Algoma Steel Corporation, Ltd., all the ores mined being first roasted in the rotary kilns at Magpie before shipment. The magnetite properties at Sellwood were operated throughout the year by Moose Mountain, Ltd., with an important production of briquettes from the milling and briquetting plant. The ore milled averaged about 33.8 per cent. in iron, while the briquettes produced contained about 61.1 per cent. iron. Shipments of less than 500 tons were made from two small properties in Eastern Ontario.

In Quebec shipments of ilmenite were made from Ivry-on-the-Lake in Terrebonne County, and of titaniferous ore from St. Urbain on the north shore of the St. Lawrence. Some magnetite was also shipped from ore dumps at the old Forsyth mine in Hull township.

In the Great Lakes region ore prices during the first half of 1918 were: Old Range Bessemer, $5.95 per gross ton; Mesabi Bessemer, $5.75; Old Range Non-Bessemer, $5.20, and Mesabi Non-Bessemer, $5.05. During the last half of the year these prices were increased by 45 cts. per ton.

Mine operators reported approximately 112,886 tons of ore exported to the United States and 93,804 tons shipped to Canadian furnaces. The Customs Department records show exports of iron ores, 130,250 tons, valued at $650,502, and imports amounting to 2,200,838 tons valued at $5,895,974.

The quantity of iron ore charged to blast furnaces in 1918 was 2,242,337 tons, of which 96,745 tons was of domestic origin and 2,145,592 tons imported. The imported ore included 754,622 tons of Newfoundland ore and 1,390,970 tons of "Lake ore."

Shipments of iron ore from Wabana mines, Newfoundland, in 1918, by the two Canadian companies operating there, were 848,574 short tons as against 883,346 short tons in 1917, all of which went to Sydney and North Sydney in Cape Breton.

Subject to a possible slight variation when final returns shall have been received the total production of pig iron in Canada in 1918, excluding the production of ferro-alloys, was 1,194,000 short tons, having a value

[1] *Prelim. Rept., Can. Dept. of Mines*, 1918.

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of $33,000,000, as compared with a total production in 1917 of 1,170,480 short tons valued at $25,025,960. Of the total production 1,163,520 short tons was made in blast furnaces and 30,425 tons manufactured in electric furnaces from scrap steel, chiefly shell turnings. In 1917 the blast-furnace production was 1,156,789 tons and the electric-furnace production from scrap steel was 13,691 tons. The recovery of high-grade low-phosphorus pig iron in electric furnaces from steel turnings was in 1918 nearly two and a half times the production in 1917, the first year that these operations were undertaken.

Pig iron was made from scrap steel in electric furnaces in three provinces: 7449 tons in Quebec and 22,976 tons in Ontario and British Columbia, the production in the latter province being a little over 1000 tons.

By grades the 1918 production included: basic, 966,409 tons; Bessemer, 15,415 tons; foundry and malleable, etc., 181,696 tons; low-phosphorus iron (electric furnace), 30,425 tons. The 1917 production included: basic, 961,656 tons; Bessemer, 14,092 tons; foundry and malleable, 181,041 tons; low-phosphorus (electric furnace), 13,691 tons.

The old furnace plant at Midland was reconstructed and placed in operation during the year. The blast-furnace plants operated included those of the Dominion Iron and Steel Co. at Sydney, N. S., the Nova Scotia Steel and Coal Co. at North Sydney; the Standard Iron Co. at Deseronto, Ont., the Steel Co. of Canada at Hamilton, Ont., the Canadian Furnace Co. at Port Colborne, Ont., the Algoma Steel Corp. Ltd., at Sault Ste. Marie, Ont., and the Midland Iron and Steel Co. at Midland.

Electric furnaces were operated for the production of pig iron from scrap steel at Hull and Shawinigan Falls, Que., at Orillia, Collingwood, St. Catharines, Toronto, Belleville and Bowmanville, Ont., and at Port Moody, B .C.

The production of ferro-alloys in Canada in 1918, chiefly ferrosilicon, but including also spiegeleisen, ferromolybdenum and ferrophosphorus, all with the exception of the spiegeleisen being made in electric furnaces, reached a total of 44,700 tons valued at $4,730,000. In 1917 the production was 43,465 tons valued at $3,549,814.

The exports of pig iron during 1918 were 2130 tons valued at $169,-495, or an average of $79.57 per ton, and of ferro-alloys 23,781 tons valued at $2,671,434, or an average of $112.33 per ton.

The imports during 1918 included 67,396 tons of pig iron valued at $2,102,406, or an average of $31.19 per ton, and 35,284 tons of ferro-alloys valued at $4,283,133, or an average of $121.39 per ton. The United States trade records show exports to Canada during 1918 of pig

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iron and ferro-alloys amounting to 122,325 gross tons valued at $5,661,-228, a figure considerably higher than the Canadian record.

The estimated production of steel ingots and direct steel castings in 1918, final returns for all operations not yet having been received, was 1,893,000 short tons, of which 1,820,000 tons were ingots and 73,000 tons direct steel castings. The total production in 1917 was 1,745,734 short tons, of which 1,691,291 tons were ingots and 54,443 tons were castings.

The production of steel in electric furnaces in 1918 was about 120,000 tons, as against 50,467 tons in 1917; 19,639 tons in 1916; 5625 tons in 1915; and 61 tons in 1914.

The total production of pig iron, ferro-alloys, and steel in electric furnaces in 1918 was about 194,000 tons.

The deposit of limonite at Alta Lake, British Columbia, which is being developed to supply fluxing material for the smeltery at Irondale, Wash., according to Charles Camsell of the British Columbia Department of Mines, covers an area of 60,000 sq. ft.[1] Analysis has shown 40.98 per cent. Fe; 0.2 to 1.80 S; 0.1 to 1.88 P; and 1.24 to 2.2 per cent. SiO_2. Other small deposits of similar ore occur in the neighborhood, originating from the decomposition of pyrite-bearing rocks.

A report on "The Commercial Feasibility of the Electric Smelting of Iron Ores in British Columbia" has recently been completed by Dr. Alfred Stansfield.

China.—An agreement has been practically concluded with the Japanese Government under which the immensely valuable iron mine of Feng Huang Shan, near Nanking, will be worked by the Chinese Government, and steel will be manufactured by Chinese and Japanese, the latter providing 20,000,000 yen to carry out the work, states the *North China Daily News.* This means that the Japanese will acquire control of the total output of the mine. At present they are pressing for the right to take part in working the mine, and, pending a decision on this point, the final signature of the agreement is temporarily delayed. The Chinese have always steadfastly refused to part with this mine, and although the Japanese have long been anxious to obtain it, it is thought that the agreement has been made possible only by a resolution of the Chinese Cabinet transferring the control of the mine from the Ministry of Agriculture and Commerce to the Ministry of War. The Feng Huang Shan mine is the largest single deposit of iron ore in China. It is estimated to contain 50,000,000 tons of available ore.[2]

The Japanese Government has definitely decided to place the development of the Chin-ling-chên iron mine in the hands of the mining

[1] *Eng. Min. Jour.*, Jan. 25, 1919.
[2] *Eng. Min. Jour.*, Feb. 1, 1919.

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department of the Shantung Railway instead of concluding a contract for this purpose with a private concern.

The Chin-ling-chên mine is located 5 miles off the Shantung Railway, 180 miles from Tsingtau. Published analyses of the ore in the time of the German occupation showed an iron-oxide content of 65 per cent., with high manganese, phosphorus and sulphur, and over 100,000,000 tons of ore present. Preparations had been made by the German authorities to erect two blast furnaces 11 miles from Tsingtau for the reduction of this ore. It is stated that 50,000 tons of ore will be mined in 1918, 150,000 in 1919, and 300,000 tons annually thereafter.[1]

The Peiyang Iron Works has been organized for the purpose of working iron mines in the Province of Chihli, China. According to the Far Eastern Bureau, the company is capitalized at $4,000,000, of which the Chinese Government will supply one-fourth, the civil governor of the province one-fourth, and merchants the remainder. The iron works will be established at Hsuanhuahsien. It is understood, also, that plans are under way in the Province of Anhui for the establishment of an iron foundry, to be called the Hua Chang Iron Foundry, for which $1,000,000 has already been raised. The office of the company will be at Penpu.[2]

A Chinese Company has been formed, of which part of the capital will be subscribed by the Chinese Government, for working the iron mines near Hsuanwafu, between Peking and Kalgan, and building blast furnaces. It is reported that the Japanese will lend 20,000,000 yen to finance the enterprise.[3]

A recent issue of the *Manchuria Daily News* contained an interesting description of the new Anshan Steel Works, now under construction by the South Manchuria Railway.[4] The new plant will be located midway between Chienshan and Lishan. Lishan is but a short distance from the Anshanchan iron field, which is to supply the necessary ore to the new works. The water supply is obtained in part from the Chienshan River, but chiefly from a subterranean stream at the foot of Shoushan Hill. To begin with, two smelting furnaces are to be constructed. These will put out 150,000 tons of pig iron per annum, which, together with scrap iron and steel, are expected to produce 150,000 tons of steel manufactures. All the buildings appertaining to the first stage of the construction work are now in course of erection.

Cuba.—Cuban shipments of ore in 1916, 1917, and 1918 were considerably checked because of transportation difficulties. Total shipments to the United States for 1918 were 632,442 tons. Shipments in recent years were as follows:

[1] *Comm. Rept.*, Nov. 5, 1918.
[2] *Eng. Min. Jour.*, Dec. 28, 1918.
[3] *Eng. Min. Jour.*, Mar. 8, 1919.
[4] *Comm. Rept.*, Oct. 3, 1918.

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Year.	Total.	South Coast.	North Coast.
1918	632,442	(a)404,000	(a)228,000
1917	546,069	.....	.....
1916	716,571	.....	.....
1915	831,618	(a)520,000	(a)310,000
1914	815,017	(a)580,000	(a)270,000
1913	1,635,622	(a)1,090,718	(a)491,713
1912	1,397,797	951,621	446,176
1911	1,163,714	775,922	387,792
1910	1,462,498	1,154,798	307,700
1909	936,132	936,132	.....
1908	620,836	620,836	.....
1907	650,174	650,174	.....

(a) Estimated.

The total stock of ore reported on hand at the end of the year 1918 was 1,263,595 tons, as compared with 1,166,934 tons for 1917.

France.—Very little has been made public as yet regarding the pig-iron and steel output of France during the war. Data available is still meagre and the figures after 1913 can be amplified but little, only the totals as shown in the footnotes to the following tables having been given out:

PIG-IRON PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911. (a)	1912. (a)	1913. (b)
Foundry	591,275	651,700	695,527	749,247	760,622	836,454	825,682	957,145
Forge	741,571	673,885	543,067	538,053	556,767	586,496	568,164	565,133
Bessemer	149,971	122,046	118,121	118,002	104,966	104,265	117,221	161,464
Basic	1,784,726	1,988,343	1,949,107	2,172,718	2,549,908	2,777,261	3,304,518	3,546,057
Special irons	51,489	152,975	85,328	54,085	60,196	122,113	56,407	81,517
Total	3,319,032	3,588,949	3,391,150	3,632,105	4,032,459	4,426,469	4,871,992	5,311,316

(a) As reported by the Comité des Forges. (b) Totals for 1916, 1917, and 1918, with no details, were 1,447,000 tons, 1,684,000 tons, and 1,297,000 tons, respectively.

IRON AND STEEL PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Wrought iron	747,900	687,249	563,745	519,200	501,100	462,681	(c)450,000	.....
Steel ingots	2,436,322	2,766,773	2,727,617	3,034,571	3,506,497	3,680,613	4,078,352	4,419,241
Finished steel	1,454,456	2,261,217	1,894,022	2,043,022	2,684,000	2,638,484	3,028,799	2,993,050

(c) Estimated.

STEEL PRODUCTION IN FRANCE
(Metric tons)

	Bessemer.		Open-hearth.	Crucible and Electric.	Total.
	Acid.	Basic.			
1905	119,526	1,345,511	775,247	.....	2,240,284
1906	108,037	1,418,525	834,815	.....	2,371,377
1907	78,771	1,669,757	1,001,463	16,782	2,766,773
1908	77,581	1,632,296	1,002,798	14,951	2,727,657
1909	76,981	1,853,327	1,080,912	23,351	3,034,571
1910	81,293	2,131,676	1,148,548	28,792	3,390,309
1911	75,158	2,389,352	1,185,345	30,758	3,680,613
1912	73,917	2,664,610	1,320,462	37,363	4,078,352
1913	76,816	2,931,072	1,368,067	43,286	4,419,241
(a)	.....	.....	.....	.....	.....

(a) Totals for 1916, 1917, and 1918 were 1,952,000 tons, 2,232,000 tons, and 1,912,000 tons, respectively.

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French iron-ore imports in 1916, 1917, and 1918 were respectively 627,603 tons, 539,938 tons, and 143,200 tons. In normal years they amounted to 1,400,000 tons. The bulk of the imports come from Spain, amounting to 132,108 tons in 1918 as against 434,664 tons in 1917. None came from Sweden, while Algeria contributed 28,645 tons in 1917 and 3350 tons in 1918.

The imports of pig iron and semi-finished and finished steel were as shown in the following table. Of the 1918 total 788,504 tons came from the United Kingdom and 1,015,356 tons from the United States; in 1917 these were 1,482,030 and 1,277,349 tons respectively; and in 1916, 1,448,894 and 1,170,832 tons respectively.

IRON AND STEEL IMPORTS INTO FRANCE
(In metric tons)

	1913.	1915.	1916.	1917.	1918.
Pig iron	32,669	166,397	612,012	657,022	375,447
Blooms, billets and bars	19,379	567,011	1,510,549	1,509,169	932,365
Wire rods	6,903	63,051	80,203	54,093	52,483
Plates and sheets	13,760	73,784	262,558	265,132	218,295
Tin plates	19,460	68,340	80,708	45,329	58,219
Wire	6,088	46,266	78,070	84,896	33,259
Rails	1,792	40,658	131,852	121,515	156,248
Totals	100,051	1,025,507	2,755,952	2,737,156	1,826,316

Exports of iron ore from France amounted to 683,460 metric tons in 1918, compared with 1,265,331 in 1917 and 745,610 in 1916; all of this was shipped to England.

The all-absorbing topic in the French iron and steel industry since the armistice has been the problem of reconstruction and the rehabilitation of destroyed French steel plants. Under the name of "Société Corporative des Mines de fer et de la Sidérurgie des régions sinistrées," a company has recently been formed in France for the purpose of conducting commercial or industrial operations useful in bringing about the reconstitution and reorganization of the iron mines and steel works of the invaded regions. The company is affiliated with the Comptoir Central d'achats industriels pour les régions envahies, and has its offices with that organization at 40 rue du Colisée, Paris.

The Société des Aciéries, of Firminy, France, in order to overcome the difficulty, during the war, of obtaining, for the manufacture of steel, an iron as pure as Swedish iron, has started the manufacture of electrolytic iron at its Rioupéroux shops. Several tons have already been obtained, and the installation of a plant of a capacity of 25 tons per day is under way. The process employed is that invented by C. F. Burgess, of Madison, Wis.

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The Savoy iron fields have been discussed by M. Albert Bordeaux.[1] He describes in great detail all the deposits, broadly speaking, within and just outside the quadrangle formed by Grenoble and Modane in the South, and Bellegarde (southwest of Geneva) and the Mont B'anc in the north, thus including some of the deposits of the Dauphiné.

Germany.—Monthly production statistics of pig iron for the war period were not made public until early in 1919. Complete data are as follows:

	Metric Tons.					
	1913.	1914.	1915.	1916.	1917.	1918.
January	1,611,345	1,566,505	874,133	1,078,368	1,082,797	933,570
February	1,493,877	1,445,511	803,623	1,036,683	943,547	892,788
March	1,629,463	1,602,896	938,438	1,114,194	1,104,653	1,039,092
April	1,588,701	1,534,429	938,679	1,073,716	1,131,620	1,084,601
May	1,643,069	1,607,193	985,968	1,112,574	1,198,171	1,181,794
June	1,609,748	1,531,333	989,877	1,079,349	1,124,998	1,182,415
July	1,648,118	1,564,345	1,047,503	1,133,092	1,190,014	1,179,947
August	1,640,016	586,661	1,050,610	1,145,239	1,185,968	1,155,084
September	1,590,849	580,087	1,034,124	1,116,752	1,119,635	1,105,366
October	1,653,051	729,882	1,076,343	1,161,005	1,076,222	1,049,837
November	1,588,985	788,956	1,019,122	1,101,311	1,007,731	516,570
December	1,511,250	853,881	1,029,144	1,161,955	1,976,891	430,478
Total	19,208,472	13,191,679	11,787,564	13,314,238	13,142,247	11,754,542

Production of pig iron by kinds for several years past is noted below. Steel pig includes ferromanganese, spiegeleisen, ferrosilicon, and similar alloys:

PRODUCTION OF PIG IRON IN GERMANY
(In metric tons)

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Foundry iron	2,881,059	3,355,177	3,640,074	2,494,832	2,283,538	2,019,991	2,012,277	1,499,882
Forge iron	689,881	525,423	489,783	370,257	278,684	216,693	246,288	173,019
Steel pig	1,547,480	2,201,489	2,599,887	1,996,786	1,793,865	2,380,308	2,446,092	2,255,312
Bessemer pig	377,051	388,855	368,840	237,988	187,522	152,660	130,019	115,689
Thomas pig	9,785,056	11,397,965	12,193,336	9,289,989	7,246,322	8,515,086	8,307,571	6,763,592
Total	15,280,527	17,868,909	19,291,920	14,389,852	11,789,931	13,284,738	13,142,247	10,807,494*

*Ten months.

The following table gives the production according to districts:

PRODUCTION ACCORDING TO DISTRICTS
(In metric tons)

	1914.	1915.	1916.	1917.	1918.
Rhenish-Westphalia	6,610,119	5,165,618	5,749,806	5,932,914	5,817,886
Siegerland and Hessen-Nassau	702,436	789,650	868,544	767,800	702,377
Silesia	853,957	777,625	784,052	751,805	909,506
North and Central Germany	734,659	602,826	663,658	860,878	771,123
South Germany and Thuringia	266,065	234,669	255,325	168,627	168,315
Saar District	954,738	801,597	944,730	898,350	708,863
Lorraine and Luxemburg	4,267,573	2,407,946	4,018,615	3,561,873	2,677,890
Total	14,389,547	11,789,931	13,284,730	13,142,247	11,755,960

[1] *Bull. Société de l'Industrie Minerale; Iron & Coal Tr. Rev.*

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The statistics of the German output of steel have also now been made public.[1] The data for the last three years, compared with those for 1913, are as follows:

	1913.	1916.	1917.	1918.
Basic Bessemer	10,629,697	7,653,990	7,294,899	5,906,460
Open-hearth	7,610,140	6,856,801	7,274,473	6,170,781
Bessemer (acid)	155,138	175,109	173,430	146,424
Crucible	99,173	108,205	129,784	79,064
Electric	101,755	190,036	219,700	221,824
Steel castings	298,338	1,198,379	1,495,074	1,232,260
Total	18,894,241	16,182,520	16,587,360	13,756,813*

* Ten months.

While the total steel output in the last three years of the war steadily declined as compared with 1913, there was a surprising increase in electric steel and in steel castings at the expense of a decrease in open-hearth and Bessemer ingot steel.

In steel of all grades Germany reached her maximum output in 1913 at 18,894,241 metric tons. The largest war production was in 1917 at 16,587,360 tons. At no time during the war did the flow of steel from German furnaces approach the peace production despite the fact that there were attempts to make the Allies think that records were being made. It is a fact that the coal production, on which munition makers and steel plants depend, was about 2,500,000 tons per month less than in peace time, while the war output of coke was equal to the peace output; but those well informed knew that the country could not maintain a pig-iron and steel production equal to the pre-war rate. Under the conditions, therefore the production of over 16,500,000 tons was no mean achievement. In the 10 months ended with October, 1918, the output was 13,756,813 tons, and if this rate could have been maintained for the other two months the year's production would have been over 16,500,000 tons.

By no means was the same ratio in pig-iron output maintained as in steel. As compared with over 19,300,000 tons in 1913, the largest war production was 13,284,738 tons in 1916. That it was possible to augment so greatly the steel output under war conditions is probably explained by the use of large amounts of scrap taken from Belgium and France in the shape of broken machinery and iron and steel in all manner of forms.

Comparing the 1917 steel output with that of 1913, it is notable that the Bessemer basic output declined over 33 per cent., due perhaps to a lack of pig iron. The open-hearth production was maintained at more than the relative normal peace output, or 7,270,000 tons as com-

[1] *Iron & Coal Tr. Rev.*, Jan. 31, 1919.

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pared with 7,600,000 tons in 1913. In crucible steel there was a marked increase relatively, and here scrap steel was probably also an important item. The expansion from 1913 to 1917 was over 30 per cent. But the striking changes are in the electric-steel and the steel-casting output. The 1917 electric-steel production was over twice that of the 1913, when Germany led the world in the use of the electric furnace. In steel castings, however, the growth was remarkable under war conditions, the 1917 output having been over five times that of 1913, or 1,495,000 tons against 298,000 tons. The extent of this expansion is appreciated when it is remembered that the German steel foundry output in 1916, 1917 and probably 1918 exceeded that of the entire United States each year. To what extent the supply of stolen scrap was a factor in the electric and steel casting output is not known, but it was probably important.

Perhaps never again will Germany occupy second place in the world's steel and iron production. The elimination of Alsace-Lorraine and Luxemburg means a drastic curtailment in the amounts credited to Germany and the quantity that will be unavailable for inland consumption as a result of the appropriation of German territory is by no means small. As a result of the war, then, Great Britain occupies second place in the world's steel and iron output, and it is probable that France, soon after her rehabilitation, will not only out-rank Germany but push hard for the second position in the world's great industry.[1]

According to *Engineering* the price of steel ingots in Germany rose from 82.5 marks per ton in 1914 to 90.0 marks in 1915, 102.5 marks in 1916, and now stands at 285.0 marks in the first quarter of 1919. The corresponding prices for plates were 97.5 marks, 105.0 marks, 117.5 marks, and 305.0 marks, respectively.

Great Britain.—The statistical bureau of the National Federation of Iron and Steel Manufacturers has issued the following table of production by grades in 1916, 1917, and 1918, in long tons:

	1916.	1917.	1918.
Forge	899,467	864,899	772,321
Foundry	1,418,824	1,162,982	1,296,394
Basic	2,290,549	3,082,562	3,166,556
Hematite	4,042,014	3,993,374	3,538,435
Spiegeleisen, ferromanganese and ferrosilicon	291,845	296,524	246,943
Direct iron castings	105,284	20,053	18,780
Total	9,047,983	9,420,254	9,039,429

The Cleveland district is credited with 2,424,139 tons of the 1918 total, most of it basic iron; the Scotland district made 1,062,645 tons, mostly hematite iron.[2]

Production of pig iron for a number of years past has been as follows:

[1] *Iron Age*, May 29, 1919.
[2] *Iron Age*, May 1, 1919.

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	Tons.		Tons.
1907	9,923,856	1913	10,481,917
1908	9,289,840	1914	9,005,898
1909	9,664,287	1915	8,793,659
1910	10,217,022	1916	9,047,983
1911	9,718,638	1917	9,420,254
1912	8,889,124	1918	9,039,429

The following table gives the output of steel ingots in Great Britain, in gross tons:

BRITISH STEEL OUTPUT BY GRADES

	Electric.	Acid Bessemer.	Basic Bessemer.	Acid Open-hearth.	Basic Open-hearth.	Total.
1912	.....	980,662	541,825	3,365,570	1,908,087	6,795,144
1913	.....	1,048,772	551,929	3,811,382	2,251,793	7,663,876
1914	.....	797,072	482,444	3,680,848	2,874,749	7,835,113
1915	.....	821,408	479,816	4,090,752	2,958,968	8,550,015
1916	.....	1,096,153	505,817	4,393,004	3,012,558	9,196,457
1917	57,156	1,059,281	602,265	4,413,843	3,421,170	9,553,715
1918	103,021	788,355	567,650	3,901,136	3,924,415	9,284,577

The production of steel castings increased from 250,364 tons in 1917 to 306,851 tons in 1918.

IRON AND STEEL EXPORTS, UNITED KINGDOM
(In tons of 2240 lb.)

	1912.(a)	1913.(a)	1914.	1915.	1916.	1917.	1918.
Pig iron	1,124,815	1,097,009	780,691	508,540	790,065	639,281	416,861
Wrought iron	142,461	137,335	90,405	.....	138,095	64,941	41,930
Sheets	762,244	762,744	566,601	286,466	277,206	172,139	.....
Plates	282,898	273,051	199,878	.....	311,452	115,765	.....
Rails	412,127	509,105	443,636	242,289	50,275	39,000	26,335
Steel shapes, etc.	361,992	368,498	300,653	489,464	617,159	428,445	.....
Tin plates	480,910	495,246	435,497	368,000	321,654	177,383	223,509
All other kinds	1,211,102	1,295,453	1,071,546	1,252,540	850,433	685,849	.....

The following returns of the United Kingdom output of finished and semi-finished steel were issued by the Iron, Steel and Allied Trades' Federation:[1]

	Long Tons.	
	1917.	1918.
Blooms, billets, slabs	2,073,178	1,992,822
Sheet and tinplate bars	1,089,749	1,301,904
Total semi-products	3,162,927	3,294,726
Rails, new	340,088	357,490
Tram rails	2,646	4,400
Sleepers and fishplates	28,445	35,623
Plates not under ⅛ in. thick	1,326,584	1,345,493
Plates and sheets under ⅛ in. thick	753,775	839,577
Blackplates	142,403	212,698
Shell steel (a)	1,746,000	996,000
Girders, joists, beams	222,440	253,113
General merchant steel	523,437	514,139
Hoops and strings	198,944	202,946
Wire rods	204,121	243,770
Tyres and axles	50,846	54,047
Steel forgings	207,848	261,031
Steel castings	202,520	306,851
Unenumerated products	837,824(b)	1,593,640
Total finished products	6,787,921	7,221,268

(a) Based on returns made to the Ministry of Munitions. (b) Subject to rectification.
[1] *Metal Bull.*

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The British Government's efforts to restrict iron and steel exports were continued well into 1919. The 1918 December exports, excluding iron ore and including scrap, were only 123,947 gross tons.

A complete statement of the iron and steel exports and imports of Great Britain for 1918 is now available. It was published in the London *Iron and Coal Trades Review*, Jan. 10, 1919. It is regarded as more complete than monthly data published during the war and compares with pre-war statistics.[1]

Total iron and steel exports, excluding ore and including scrap, were 1,617,917 gross tons as compared with 2,344,801 tons in 1917. The corresponding total in 1913 was 5,049,090 tons.

Pig-iron exports for 1918 were 416,861 tons as compared with 638,281 tons in 1917. In 1913 they were 945,262 tons. Exports of spiegeleisen, ferrosilicon and ferromanganese, principally the latter, were 66,279 tons in 1918 as compared with 94,477 tons in 1917. In 1913 these were 178,919 tons.

Tin-plate exports last year were 223,500 tons, but they were only 177,383 tons in 1917. Both years show a decided shrinkage from 1913, when they were 494,497 tons. France and Australia took the larger portion of the 1918 outgo.

The exports of steel bars in 1918 were only 160,845 tons as compared with 428,452 tons in 1917. France took over 70 per cent. in both cases, probably largely shell material. In 1913 these exports were 251,059 tons.

The galvanized sheet outgo dwindled to small proportions compared with pre-war trade. In 1918 the total was only 8835 tons as against 18,926 tons in 1917, but 762,075 tons in 1913.

Rail business has also fallen off, the exports having been only 26,335 tons in 1918 and 38,900 tons in 1917 as compared with 500,117 tons in 1913.

Exports of plates over $\frac{1}{8}$ in. thick were 111,744 tons in 1918 and 102,288 tons in 1917; in 1913 they were 133,949 tons.

Steel blooms exported in 1918 totaled 70,380 tons against 163,221 tons in 1917. These contrast with only 4478 tons in 1913.

Machinery exports of all kinds in 1918 were 134,953 tons, valued at £11,455,047, as compared with 199,101 tons in 1917, valued at £11,421,653. In 1913 these were 537,636 tons, valued at £24,762,019.

Import statistics show that 6,442,254 tons of iron ore was imported in 1918, of which 4,327,114 tons came from Spain. In 1917 this total was 6,054,594 tons, Spain contributing 4,171,582 tons. In 1913 the iron-ore imports were 7,442,249 tons. The data also now give the manganiferous iron-ore imports. In 1918 these were 123,606 tons, 190,186 tons coming from Spain. The total in 1917 was 135,061 tons, 80 per cent. from Spain.

Steel blooms, billets and slabs imported in 1918 amounted to 20,046 tons against 58,402 tons in 1917. Of these the United States furnished 12,393 tons and 49,177 tons in 1918 and 1917 respectively. In 1913 these imports were 513,988 tons, of which 312,223 tons came from the United States.

Pig-iron imports in 1918 were 104,362 tons and in 1917 they were 141,486 tons. In 1913 these were 216,708 tons. Ferro-alloy imports, probably largely ferrosilicon, were 24,992 tons in 1918 as compared with 13,640 in 1917. They were not recorded separately in 1913.

[1] *Iron Age*, Feb. 27, 1919.

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Manganese-ore imports last year were 365,606 tons as compared with 331,264 tons in 1917.

Total iron and steel imports, excluding ore and including scrap, were 342,516 tons in 1918 and 519,439 tons in 1917. The total in 1913 was 2,343,173 tons.

Holland.—According to a writer in *Ingenieur*, deposits of bog ore have been worked along the courses of rivers (the Yssel, etc.) and other watercourses in several places in Holland for about two centuries up to well into the second half of the past century. After the invention of the basic Bessemer process these ores were exported to and smelted in large quantities in Germany.

It is now proposed to establish an iron and steel works at Ynuiden, Holland, comprising a blast-furnace plant and rolling mill; the title of the new company will be the Royal Netherlands Blast Furnace and Steel Works, with its headquarters at the Hague, and with a capital of 25,000,000 florins.[1]

India.[2]—A new blast-furnace plant will be erected in India by the Indian Iron & Steel Co., Ltd., Calcutta, which has been organized with a capital stock of £1,000,000. The plant will consist of two 350-ton blast furnaces, a by-product coke plant with a daily capacity of 1000 tons, a recovery plant for the manufacture of coal tar and ammonium sulphate, and a plant for the manufacture of sulphuric acid used in the recovery processes. The plant will be located at Asansol in the Bengal coal fields, about 130 miles from Calcutta, where the company will operate its own collieries. It has acquired 250 sq. mi. of iron-ore properties which are located about 130 miles from the site of the plant. Both foundry and basic iron will be made.

Italy.—The pig-iron output of Italy in 1917 as compared with 1916 was as follows, according to *Rivista del Servicio Minerario*, in metric tons:

	1917.	1916.
Coke pig iron	410,224	443,464
Charcoal pig iron	4,440	6,630
Electric pig iron	56,524	17,298
Totals	471,188	467,392

The steel output was as follows, in metric tons:

	1917.	1916.
Bessemer steel	23,200	39,581
Open-hearth steel	1,235,962	1,182,417
Crucible steel	1,290	710
Electric steel	36,948	22,376
Castings	35,441	24,402
Totals	1,331,641	1,269,486

[1] See also MINERAL INDUSTRY, 26, 364 (1917).
[2] *Iron Age*, Feb. 13, 1919.

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The iron-ore output in 1917 is reported as 993,825 tons as compared with 942,244 tons in 1916. The large production of electric pig iron in 1917 is striking.

Japan.—The output of pig iron and steel in Japan from 1911 to 1916 is given as follows in gross tons by one of the best authorities, the British Iron, Steel and Allied Trades' Federation:

	Pig Iron.	Steel.
1911	52,224	10,060
1912	55,448	12,254
1913	55,765	13,510
1914	72,882	15,142
1915	63,954	16,500
1916	76,058	23,483

The following table shows the imports of iron and steel:[1]

	Tons.		
	1915.	1916.	1917.
Pig iron and ingots	173,883	243,182	235,221
Bars, rods, shapes, etc	68,082	161,268	221,243
Plates and sheets, uncoated	77,569	159,881	296,816
Galvanised sheets	7,270	4,842	4,285
Tinned sheets	26,495	38,993	26,635
Wire, galvanised	21,812	18,313	18,449
Nails	3,482	21,218	9,358
Pipes and tubes	8,996	16,721	26,951
Rails	8,920	4,344	50,671

The extent to which American trade with Japan in iron and steel expanded in war time is phenomenal. This expansion has been in many products, but more particularly in steel plates and sheets, tin plate and machinery. In 1913 Japan took but 7250 gross tons of American steel plates and sheets, but in 1918 that country received 120,395 tons of steel plates and 53,862 tons of sheets, or 174,257 tons of both, twenty-four times the pre-war consumption. Still more striking was Japan's absorption of steel plates at the height of the war. In 1917, out of total exports of 525,660 tons of steel plates from the United States, Japan was credited with 257,709 tons, or about 50 per cent. In tin plate and machinery the trade with Japan has also shown a marked increase. In 1913 Japan received from the United States only 227 tons of tin plate; in 1918 this had grown to 36,643 tons, or sixteen-fold. Japan's imports of rails were four times greater in 1918 than in 1913, and the use of cast and wrought pipe and fittings from 1916 to 1918 expanded over threefold.[2]

Java.—The discovery of large iron fields in the middle Celebes, in what is known as the lake district, has created a stir in mining circles of Netherlands India, according to Consul A. E. Carleton, at Batavia.[3]

[1] *Iron & Coal Tr. Rev.* [2] *Iron Age*, July 3, 1919. [3] *Comm. Rept.*

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The latest details from government investigation substantiate the original reports as to the extent and value of these deposits.

An exhaustive study has been made of the Larona district, which is situated near the outflow of the Towoeti Lake. The Larona field occupies a surface of approximately 2.7 square miles. The other fields in this district are either less important or less favorably situated for exploitation. Further investigation of iron-ore fields in other parts of the archipelago will be made by the Government.

It is claimed that the Larona ore is similar to that of Cuba and the Philippines. With the exception of the chemical composition, the physical properties of these ore beds are equal to the Cuban. This district is said to yield common iron ore, chrome iron, nickel, and manganese ore. The average grade of the ore is 49 or 50 per cent. iron.

It is known that the quantity of iron ore in the Larona field is at least 5,000,000 tons of surface ore and 155,000,000 tons of clay ore, a total of 160,000,000 tons; but the estimate may reach 7,000,000 tons of surface ore and 206,000,000 tons of clay ore, a total of 213,000,000 tons. The ore can be extracted easily and cheaply. The fields cover a large territory, but the ore layers do not extend more than 46 ft. in depth.

Luxemburg.—In 1917 the Duchy of Luxemburg produced 4,276,550 tons of iron ore, compared with 6,752,207 tons in 1916.[1] The average selling price per ton of ore in 1917 was 4.17 fr. against 5.41 fr. in 1916. The reduced output was due to the fact that the Luxemburg blast furnaces were compelled to restrict their production of pig iron, owing to the inadequate supply of coke. The only available export market was Germany, where the competition of the Lorraine works was keenly felt.

The production of pig iron in Luxemburg was 1,957,500 metric tons in 1916, 1,541,730 tons in 1917, and 1,183,918 tons in the first 10 months of 1918.

Norway.—Production of iron ore in 1916 was 879,840 metric tons, as against 714,917 tons in 1915, and 652,273 tons in 1914.

Iron-ore exports in 1917 were 197,800 tons, as compared with 404,700 tons in 1916, and 425,900 tons in 1915. The output of ferrosilicon in 1917 was 29,340 tons, with 25,256 tons credited to 1916 and 9308 tons to 1915.

Despite large resources of ore, Norway has an iron famine, largely due to the lack of coal. There are, however, large water powers in the country which could be developed for the smelting of iron. A plan is now on foot for the utilization of 2500 hp. for smelting ores of the Braastad Mines, where ores are especially rich and well adapted for this process.[2]

Poland.—In Russian Poland before the war there were, according to

[1] *Ironmonger.*

[2] *Iron Age*, Feb. 13, 1919.

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Stahl und Eisen, eleven blast furnaces, 27 open-hearths, 62 reheating and 25 puddling furnaces. At Dombrova, where the furnaces were blown in again last fall, the chief works are Huta Bankowa, which previous to the war had Russian support, as the operating company was French. Rails, axles and wheels came solely from these works, the others supplying mainly sheets and merchant iron. Two spelter works which belonged to the Société Minière Franco-Russe are also at Dombrova.

The inadequate supply of ore from South Russia placed the Polish furnaces before the war at a disadvantage compared with those in South Russia, but the German periodical states that Austrian ore will be furnished the Dombrova stacks as far as possible. The lack of raw materials will probably continue to prevent the blowing in of other furnaces, though the important Milovitz iron works, which formerly produced mainly merchant iron, wire and railroad accessories, has repeatedly sought permission to resume operations. An expansion of its plant by this company a few years before the war has so far been useless to it. There are even some firms belonging in whole or part to German interests that are in similar straits owing to the lack of raw materials.

Russia.—The output of pig iron and steel in Russia from 1907 to 1917 was as follows, in metric tons:

	Pig Iron.	Steel.
1907	2,723,000	2,600,000
1908	2,749,000	2,628,000
1909	2,817,000	3,071,000
1910	3,040,000	3,479,000
1911	3,521,000	3,870,000
1912	4,197,638	4,498,193
1913	4,557,000	4,837,000
1914	4,257,000	4,732,000
1915	3,690,000	4,900,000
1916	3,737,593	.....
1917	3,000,000	.....

Of the 1914 steel output, 3,860,000 tons was open-hearth and 832,000 tons Bessemer steel. Crucible steel was 8000 tons, and there was no electric steel reported.

Iron Works in the Donetz Basin of Russia are practically intact, and with some repairs would be able to resume operations immediately if the conditions permitted, according to the *Ironmonger*. Last August the blast furnaces of Krivoi Rog at Gdanzevski, were undamaged, but only 400 men remained at work. At the Briansk works 2500 men out of 6000 and at the Druzhkovka works 3000 men are employed. The Dnieproviénne Co. has kept on its men at the Kamenskoi furnaces, and it is possible that work may soon be resumed there.

South Africa.—As a result of conditions due to the war South Africa is at last about to enter the ranks of the world's iron producers.[1] Two small blast furnaces are actually on the point of being blown in, and two

[1] *So. Afr. Min. Eng. Jour.*, Feb. 15, 1919.

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others are expected to be in operation within the next two or three months; so that what was considered a few years ago as being without the bounds of commercial practicability will shortly be an accomplished fact. The sedimentary iron ores of the Pretoria series and Karroo system afford the bases of all four ventures. The furnaces already completed are those of the Pretoria Iron Mines, Ltd., and of the Transvaal Blast Furnace Co., Ltd. The former company proposes smelting in a 50-ft. furnace, with coke prepared from Dundee coal, a mixture of silicious and "clay-band" ores from the lower portion of the Pretoria series. The silicious ore assays from 40 to 54 per cent. iron, and from 14 to 22 per cent. silica, sulphur and phosphorus being both very low, and titanium present in traces only. The "clay-band" ore assays from 50 to 55 per cent. iron, from 7 to 9 per cent. silica, and from 0.5 to 0.6 per cent. phosphorus. Both types of ore can be very cheaply mined, and are available in enormous quantity, millions of tons of the silicious iron-stone being actually in sight. Limestone from Taungs, in Bechuanaland, is to be used as flux. The furnace has a capacity of from 12 to 15 tons of pig iron per day. The Transvaal Blast Furnace Co., which has erected a 50-ft. blast furnace at Vereeniging in connection with the Union Steel Corporation, intends smelting a very pure bedded magnetite ore, found in the Transvaal coal measures on the farm De Roodepoort, No. 67, 7 miles east of Ermelo. The ore to be smelted at Vereeniging is the purest iron ore yet discovered in South Africa, assaying from 66 to 69 per cent. iron and from 0.5 to 1.5 per cent. silica. Sulphur and phosphorus are low, and it is quite free from titanium. The tonnage in sight, however, is not very great. A third Transvaal company, proposing to undertake the production of iron and steel, is the Locale and Industrielle Maatschappij of Pretoria, which has leased a large area of the Pretoria town lands adjoining the lease of the Pretoria Iron Mines, Ltd. The other blast furnaces referred to are in Natal, one at Wentworth, a suburb of Durban, and the other at Sweetwaters, near Maritzburg. In both instances sedimentary iron ores from the Ecca beds of the Karroo system are to be smelted. That for the Wentworth furnace is being quarried at Elvarston, while at Sweetwaters it is proposed to use a mixture of local ore and Ermelo magnetite. The progress of these smelting ventures, at least two of which are merely the forerunners of far more ambitious projects, will be watched with the greatest interest, as it is generally recognized that an established iron and steel industry would be of the utmost benefit to the whole of South Africa. The available reserves of these ores are practically inexhaustible—estimated to be at least 2,000,000,000 tons—and if they could, as suggested by Stanley, be smelted on a large scale in admixture with the silicious ore of the Pretoria series—of

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which it is estimated that there are some 1,000,000,000 tons available—using cheap non-coking Transvaal coal as fuel, South Africa should be able to export iron and steel in competition with the great iron-producing countries of the world.

Spain.—Exports of iron ore in 1918 were 4,292,406 tons, as compared with 5,137,621 tons in 1917, 5,148,127 tons in 1916, 4,508,213 tons in 1915, 6,083,193 tons in 1914, and 8,907,202 tons in 1913. Exports of manufactured iron and steel were 47,176 tons in 1917, as compared with 69,045 tons in 1916.

Following are the imports of iron and steel, according to *Revista Minera:*

	Metric Tons. 1917.	1918.
Pig iron	14,700	6,452
Cast iron	255	118
Rails, bars, sheets	10,222	6,294
Tinplates	1,241	877

The production of iron ore in Spain, especially in the province of Vizcaya, of which Bilbao is the commercial center, is declining. The decline is due to difficulties in working the mines, the scarcity of tonnage and the dangers of navigation. The ore waiting shipment at the ports much exceeds the available cargo space, and, owing to the dangers of navigation between Bilbao and England, owners prefer to send their ships to the East or to the United States. In 1917, 711 ships left with ore from Bilbao and 82 from Castro Uridales. The smallest exports were in February of that year, when the submarine campaign began without previous warning.

The output of the Vizcaya iron mines in recent years was 3,034,628 tons in 1914; 2,778,580 tons in 1915; 3,238,022 tons in 1916 and 2,750,904 tons in 1917.

Spitzbergen.[1]—The enormous coal and iron beds in Spitzbergen belonging to the British company, The Northern Exploration Co., Ltd., have been investigated by experts who declare that the iron beds are without exception the largest in Europe. Whole mountains of massive iron ore are said to have been observed, covering a distance of over 17 miles and situated on good harbors in which ships of any size can enter.

Sweden.—The output of iron and steel in Sweden in 1918, according to statistics published by the Association of Swedish Iron and Steel Works, was as follows, in metric tons, as compared with 1917:[2]

	1917.	1918.
Pig iron and direct castings	821,200	749,800
Puddled iron, blooms, etc	114,100	92,000
Bessemer ingots	76,900	66,500
Open-hearth ingots	489,700	458,300
Rolled and forged iron and steel	378,000	361,400

Comm. Rept.

[2] *Iron Age*, May 1, 1919.

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In 1918 Sweden exported 4,486,000 tons of iron ore as compared with 5,613,000 tons in 1917. The pig-iron exports were 180,113 tons in 1918 as against 231,244 tons in 1917. The total iron and steel exports in 1918 were 183,753 tons, which compare with 230,204 tons in 1917 and 299,086 tons in 1916.

Sweden has a special position in the iron industry of the world. High qualities of iron are produced, and they are exported to all parts of the world. The general condition of the iron market has its influence on Swedish iron, especially on the iron-ore export trade. The greatest interest now is the export of quality iron. On account of the blockade, countries that formerly imported Swedish iron have had to get along on their own resources. This has been done by electric-refining processes, which have been used greatly, especially in England and America. Sheffield, which for years was one of the most important users of Swedish steel, and which formerly had only 3 electric-steel furnaces, now has 80. The question is whether these electric ovens in the future will be able to compete with the Swedish steel. This electric-iron industry is not a substitute industry, but something that has come to stay, and Sweden will undoubtedly feel its competition, although it is a question whether in all ways it will be able to displace Swedish steel. Sweden itself has a good basis for the electric processes in its waterpower. Its iron industries, however, are often located in places where great waterpower is not available. In this connection we may mention the development of the Dalälvens and Klarälvens waterpower, and the purchase by the middle Swedish iron industries of the Krangedeforsarne and the general iron works at Lulea.

With regard to Sweden's own requirements of ordinary iron, she has long desired to cover it with her own production instead of with imports. It may be a question whether the possibilities for doing this have not been decreased by the war. Manufacture of ordinary iron must be based on imported fuel, and it is probable that the high prices of this fuel will persist for a long time. To this difficulty must be added high transportation costs and a future depression of the iron market generally. It seems, therefore, that the largest part of the iron industry must continually follow its old traditions with regard to high quality, and that it must do everything in its power to strengthen further its historical leadership in this respect.[1]

Ukrainia.—According to figures published by the German Consulate at Ekaterinoslav, the production from the Krivoi Rog and the number of workmen employed since 1913 have been as follows:[2] 1913—6,300,000 poods, 23,000 workmen; 1914—4,800,000 poods, 12,500 workmen; 1915

[1] *Comm. Rept.*, Dec. 26, 1918.

[2] *Min. Jour.*, Dec. 28, 1918.

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—3,800,000 poods, 19,000 workmen; 1916—5,000,000 poods, 25,500 workmen; 1917—3,500,000 poods, 18,000 workmen. The Gdanthevaski Works in Krivoi Rog are reported to have been undamaged as late as last August. The Mariupol Works at Nikopol ceased operations last May, as did those of the Donetz-Yurievka. A small output was maintained up to a recent date at the Bryansk Works and at the Druikovska. The Kamenskoye Works on the Dnieper, having retained their staff, were in a position to resume at an early date.

TECHNOLOGY

General Conditions.—The iron and steel industry of the United States was so entirely absorbed in producing steel for war purposes in 1918 that practically no time was left for metallurgical or scientific matters, at least so far as surface indications go. As in 1917, only more so, any recorded advance was largely of a commercial nature. Production was pushed to the limit in both pig iron and steel. Very little time was devoted even to the necessary repairs to plants. Throughout the year and even for some time after the signing of the armistice, the maximum prices for pig iron and all of the principal grades of steel products were rigidly maintained.

It is probably true that considerable progress was made in the metallurgical phase of the industry. But much of this was due to war study and research and a good deal of it cannot come out until peace has been assured. The revelations will doubtless be striking, as evidenced by some facts already made public or hinted at. The work of the National Research Council has been prominent and its revelations may be epoch-making.

Blast Furnace.—Nothing that can be considered revolutionary in its influence on blast-furnace practice or its future came to the surface in 1918. Efforts were made to establish the Cottrell precipitator as a necessary unit in blast-furnace plants. Its success, however, as a blast-furnace installation will no doubt be limited to plants consuming ores, coke and limestone of high potash value. The Dorr thickener attracted considerable attention during 1918. This machine bids fair to prevail in many plants where gas-wash-water is required to be kept very clean, such as where discharged into shallow rivers and canals. It will easily pay for itself in the salvage of thousands of tons of very fine particles rich in iron, to be briquetted for recharging into blast furnaces.

Recent tests on the use of hard (magnetic) ores in steep-bosh furnaces indicate that the old theory of a flat bosh, say 72° to 74° for hard-ore furnaces, is not well founded. There is some reason to believe that at the time when stock distribution was not considered of most vital importance, and of hit or miss methods of keeping furnaces full, of adherence to

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concentric rings instead of modern bells, without regard to relation between diameter of bells and stockline, etc., the flat bosh or rather small hearth may show improved practice, due to penetration of blast. This, however, is a case of using one evil to cure another and is still practised at many furnace plants.

Especially in the past year, more attention has been given to general practice and improvement in details. Inferior coke, as well as poorly conditioned flux, due to lack of control in the management of labor, no doubt brought many plants up to more scientific operation. This statement will be borne out by numerous recommendations to the effect that sulphur specifications in both steel and pig iron be made lighter.

The Brassert washer is coming into its own in cleaning of gas for stoves and boiler use. This washer, cleaning gas almost to gas-engine requirements, is enabling many plants to change their stove checkers to sizes as low as 3-in., whereas formerly a 9-in. checker had been considered practically the minimum. This means much in economy of furnace gas and reduction of stove equipment.

Increased usage of low-volatile coals in coking practice has brought out more than ever the necessity of clean coke for furnace use. In a number of plants, however, coke screens have been opened up from ¾ to 1-in. size.

Blast-furnace Potash.—One of the remarkable metallurgical and economic results of the war has been the production of potash salts as a by-product from sources hitherto passed by, and Great Britain has the distinction of having developed in this way an output equal to its entire pre-war needs. The iron blast furnace is furnishing a large part of the new supply. That blast-furnace dust contains potash salts which are recoverable in commercial quantities was discovered by an American blast-furnace superintendent, R. J. Wysor,[1] and has been the incentive of widespread investigation. In Great Britain the results have been striking. The ores there used seem to be especially adaptable to the recovery of potash, and it is an interesting fact that the addition of salt to the charge has increased the output. At one plant large quantities are produced each week, and it is stated that the country's output can easily be increased to 50,000 tons a year, or enough to satisfy all demands.

An American investigator, Linn Bradley, recently called attention to the fact that Southern iron ores, particularly those of Alabama, can be made a prolific source of potash. And at a recent convention of the National Fertilizer Association in New York it was shown that this year's output of potash would largely exceed the 1917 output of 32,000 tons and that it would "be possible, by mobilizing all the raw material

[1] MINERAL INDUSTRY, 25, 432 (1916).

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of blast furnaces and cement mills, to reach an annual production of 500,000 tons." This is nearly twice as much as formerly came from Germany, the world's principal pre-war source. Our imports just preceding the war were over 283,000 tons.

Cast-iron Piston Rings.—An interesting development during 1918 was the announcement of a new method of making cast-iron piston rings.[1] Briefly the process consists in pouring liquid iron into a rapidly revolving permanent mold. The iron is thrown to the outside where it congeals in the form of a practically finished piston ring. After annealing, the rings possess unusual properties as compared with those cast in sand. A feature of the process is the speed of manufacture. About 16,000 to 18,000 are being made each day in the plant of the Standard Piston Ring Co., at Newark, N. J. The fastest sand-molding machine is understood to be able to turn out only about 420 rings per day.

Ferro-alloys.—France before the war led in the production of ferro-alloys, particularly as made by the electric process. Paul Girod was a pioneer in this field, and his products were introduced in all steel-making centers of the world. Germany occupied a less prominent position, but her work in this line was growing in importance, particularly as regards control of the tungsten resources of Great Britain and as a seller of ferro-tungsten to other countries. Great Britain had not yet awakened to the possibilities of ferro-alloys and the United States was not far ahead of her.

A striking transformation has taken place in the last four years. At the end of 1918 without doubt the United States led the world in the production of all kinds of ferro-alloys. More ferromanganese is produced here than in any other country and it is not improbable that we may partly displace Great Britain as an exporter to Canada. These exports grew larger with each month during the war. In electrically made ferromanganese rapid strides were made here. And in ferrosilicon, both high and low grades, decided progress has been made quite recently in the electric product.

In other ferro-alloys, particularly those of tungsten, chromium and molybdenum, as well as of vanadium and uranium, development has been noteworthy in this country as the war has progressed. Much of this expansion has taken place in Colorado, Utah and Montana, and also in California. The movement has become one of national significance particularly in the West. In addition, the ferromanganese developments of Montana and the Western Coast have been important. In ferro-chromium California occupies a new and prominent position.

Not only as a producer and user but as an exporter of ferro-alloys the United States has taken a new position. Before the war our steel

[1] *Iron Age*, Oct. 3, 1918.

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companies were importers of ferrotungsten, but for 1918, the exports were 1,232,260 lb. Very little ferrovanadium was exported before the war, but in 1918 the amount sent abroad was 1,512,737 lb. and in 1917 it was nearly 2,500,000 lb. Most of the ferromolybdenum now made here is also exported, and the demand from foreign countries for our ferrotitanum in the war period has been remarkable.

The future of this industry is hard to forecast. The electric furnace has made its growth possible, as well as furthering the development of new products. Indications are that ferrozirconium will soon occupy an important place among ferro-alloys. The use of alloy steels has grown phenomenally and is bound to expand.

Steel for Guns.—The metallurgy of gun steel has been greatly altered as a result of the war. This is particularly true in this country. As the war drew to a close steel for large guns was being made in a radically different manner from what was thought possible, even early in the war. In both England and this country it was accepted practice, four years ago or less, that only acid open-hearth steel could be safely incorporated in ordnance. The gun plants especially built in this country after our entrance into the war adopted this process. The reason was that it was thought possible by this process alone to make unusually pure and reliable metal. The great disadvantage involved, however, is the length of time to produce a heat of such steel. The complete deoxidation, the formation of the proper slags and the refinement of the metal consume from 13 to 15 hours for a 40- or 50-ton heat, with the utmost care necessary. As the development of the ordnance program of the United States progressed it was found that the large electric furnace, refining hot metal on a basic bottom, could and did produce gun steel equal if not superior to that made by the long-drawn-out acid open-hearth process.

While a 3-per cent. nickel steel was the standard alloy used for many of the guns, it is known that at one of the large British plants a plain carbon electric steel was giving entire satisfaction in the last months of the war. An interesting report, also, is that at one American plant gun steel that met ordnance specifications satisfactorily was being made in basic open-hearth furnaces—a steel that was tabooed for guns before the war. No doubt, had the war continued much longer, the electric furnace would have been the first choice for the production of ordnance steel. It was already so employed in the Chicago district and was scheduled for some of the later gun plants. And this was not so much because of the superiority of electric to acid open-hearth steel, but because the same amount of suitable metal can be made in about one-third the time by the former process, and in preparing for and prosecuting a war it is time as well as quality that counts.

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Progress in Electric Steel.—Interesting features have marked the progress of the American electric steel industry in the last two years, as shown in the statistical details given on a preceding page. The war has been the propelling force behind the expansion of this comparatively new industry. Had the world conflict lasted only a few months longer the 1918 record of furnace installations would have shown a much larger growth. The same is true of the output. But war cannot be necessary to the growth of this industry. Some contend that its expansion in this country has stopped because electric power is too expensive under normal conditions. But consumers have been educated to the high quality of electric steel and its peculiar adaptability to certain conditions has been demonstrated. Perhaps its greatest future lies in the duplex or triplex processes. Certain it is that the process has come to stay, and will remain in some way. A portent of the future is that inquiry for such furnaces is now much more intensive than was expected some time ago.

Heat-treated Electric Cast Steel.—A recent development in the metallurgy of electric cast steel may have an important bearing on the future of this industry. It is the successful manufacture of a special steel which has been used in a new type of chain called electric-steel anchor chain, and also in draw-bar or coupler knuckles. When heat-treated this steel in these forms has unusual properties, particularly a high elastic limit and also superior fatigue-resisting powers.

Because of the great and sudden expansion in our shipbuilding program, it was found that the country's capacity in wrought-iron chain was only 33 per cent. of that needed. Steel foundrymen have solved the problem from both a foundry and metallurgical standpoint. The first public presentation of this subject was made at the meeting of the American Society for Testing Materials at Atlantic City in June, 1918.[1] Tests of the chain prove it to be fully equal to and in many respects better than wrought-iron chain. But a short time ago it would not have been thought possible to cast a steel chain equal even to the old wrought-iron chain, so laboriously made.

The selection of a material for such chain was due largely to the experience of one prominent company which has been making cast-steel heat-treated draw-bar knuckles which have met with unusual success. The statement is made that of over one million of such knuckles in use not one has failed in service. The stress and shock to which such material is subjected are unusually severe.

The steel used in both the chain and the knuckles is an easy and inexpensive one to make and is an unusually simple alloy steel, the composition of which is not generally divulged. The significant fact is the

[1] *Iron Age*, July 4, 1918.

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more extended application of heat treatment to steel castings. Another phase of this subject is the substitution of heat-treated alloy-steel castings for forgings. The later development here referred to is but another example of the same tendency. In general, steel castings are only annealed, but the possible results of heat treatment, especially of alloy castings of all kinds, are of more significance than has been commonly supposed.

Moving Photomicrographs.—The moving picture has entered a new field. When it first appeared few could have imagined that it would ever be applied microscopically in metallurgy. What was probably the first instance of this kind was one of the surprises of the annual meeting of the testing engineers at Atlantic City in June, 1918. The various changes in structure and the results of stresses taking place in wrought iron when subjected to repeated bendings were shown with admirable skill and effect.

Professor H. F. Moore of the University of Illinois, who took the picture, has probably introduced a method of investigation of far-reaching importance, both technically and practically. It is believed that the new idea will be successfully applied to steel, non-ferrous metals and various alloys in the near future. Besides explaining many interesting phenomena, not now fully understood, it may settle some controversies which otherwise would remain open much longer. It may determine just how steel begins to deteriorate under stress, whether through the crystal or in some other way. A solution of this problem might lead to a heat treatment prolonging the life of certain steels and making them less liable to fatigue. The moving photomicrograph may show also whether in plastic deformation of steel the change is due to slip bands or, according to the other contention, to a change in orientation. Applied to brass and special alloys, where crystal formations are large and definite, it may give important results.

Professor Moore has rendered a distinct service and may have opened up a broader field than is now realized.

New Steel from Old.—Not so long ago the possibility of making new or good steel solely from old steel or scrap, without the addition of virgin metal as pig iron, was regarded as a dream, at least so far as any commercial aspect was concerned. But there is no longer anything unusual about this. The electric furnace has revolutionized our ideas of this as well as of some other metallurgical phases of the steel industry. Today, steel of the best quality is made in large units from scrap of poor quality and from scrap alone, in such furnaces. Even old steel is almost magically reconverted into excellent pig iron, something that would have been considered chimerical if suggested ten years ago.

Something similar to this achievement of the electric furnace is now

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accomplished on a large scale in the open-hearth. In two instances, one in Canada and one in the United States, heats as large as 25 tons are being made where 95 per cent. of scrap steel, mostly shell turnings, is the charge. While about 5 per cent. of pig iron is used in one case, in the other none or very little has been employed, but instead petroleum coke has furnished the necessary carbon. It is understood that good steel has been the product in each case, the process involved being acid, and the product cast-steel shell blanks. The procedure has been nearly normal, and very little time has been lost because of the unusual practice. This condition has been largely forced because of the difficulty in obtaining low-phosphorus pig iron and because of the abundance of shell and other turnings.

Necessity is again the mother of invention. War necessity certainly has opened the way to results hitherto regarded impossible.

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LEAD

By Ernest E. Thum

A severe world shortage of lead was felt during the last few months of the war, notwithstanding an apparent glut in the market toward the end of the preceding year, 1917. Production was pushed to the utmost at all mines and smelters, but hampered by the scarcity of labor, its inefficiency and high price, but more particularly by the scarcity and poor delivery of needed supplies, the maintenance of record production was impossible. Prices were controlled either by government action, or by agreement of producers in such a way that a runaway market did not follow the shortage of supply.

World Production

World production, outside of Germany and her allies, was not greatly in excess of one million metric tons, as is shown in the following table of approximate quantities. Decrease in American production was counteracted by an increase from Australia and Mexico. The principal omissions are Great Britain, Greece, and France. French and British smelters derive considerable ore from Spain and Australia, but ore shipments from the east have been few during the last two years—bullion itself accumulated on the docks for lack of bottoms. Most of the Mexican lead went to Great Britain, both that which was smelted locally and in the United States.

LEAD PRODUCTION OF THE WORLD
(In metric tons)

Year.	Australasia. (a)	Austria. (a)	Belgium. (a)	Burma. (g)	Canada. (a)	France. (a)	Germany. (a)	Greece. (a)	Hungary. (a)
1904	117,895	12,645	23,470	.....	17,241	18,800	137,580	15,186	2,104
1905	106,418	12,968	22,885	.....	25,391	24,100	152,590	13,729	2,146
1906	93,557	14,846	23,765	.....	24,580	25,614	150,741	12,308	1,925
1907	96,608	13,598	27,450	.....	21,660	24,800	164,079	13,814	1,468
1908	119,207	12,669	35,650	.....	19,593	26,112	164,079	15,892	1,544
1909	77,992	12,941	40,306	.....	23,295	26,927	167,920	14,948	1,590
1910	105,897	15,476	40,715	.....	14,967	20,226	159,851	16,710	2,077
1911	105,397	18,097	44,308	.....	10,791	23,635	161,287	14,234	1,583
1912	113,710	19,993	54,940	.....	16,226	31,080	192,618	14,498	1,605
1913	(d) 116,000	22,312	53,590	.....	17,089	(d) 28,000	(d) 181,100	18,309	(e) 1,790
1914	.....	.....	45,560	.....	16,487	.....	.....	20,684	1,368
1915	.....	.....	16,770	.....	21,009	.....	.....	11,595	.....
1916	(g) 139,000	.....	15,560	11,266	18,823	.....	.....	9,424	.....
1917	(g) 160,000	.....	22,745	17,137	14,776	.....	.....	36,558	.....
1918	(g) 175,000	.....	.....	21,107	19,883	.....	.....	.....	.....

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Year.	Italy. (a)	Japan. (a)	Mexico. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a)		United States.	Totals. (f)
						Foreign Ores.	Domestic Ore.		
1904....	23,475	1,803	(e) 95,010	185,862	589	6,888	20,155	278,634	957,427
1905....	19,097	2,272	(b)101,196	185,693	576	7,517	20,977	290,472	988,727
1906....	21,268	4,305	(b) 73,699	185,470	753	6,984	22,691	323,567	986,980
1907....	22,978	3,067	(b) 76,158	(d)185,800	813	10,880	24,850	322,854	1,011,397
1908....	26,003	2,910	(b)127,010	188,062	277	11,480	21,336	284,858	1,057,205
1909....	22,133	3,429	(b)118,186	179,993	166	8,056	22,822	329,690	1,056,326
1910....	14,495	3,907	(b)120,662	190,523	355	8,933	21,866	353,186	1,093,043
1911....	16,684	4,160	(b)124,605	189,810	1,134	10,048	18,279	368,301	1,108,880
1912....	21,450	3,613	(b)109,717	232,612	1,073	(e) 8,255	19,473	376,947	1,212,252
1913....	21,674	(d)3,600	(b) 55,530	(d)203,000	1,235	(d)30,500	18,462	396,034	1,142,264
1914....	20,464	4,563	.....	.....	1,396	.....	19,684	485,011	.....
1915....	21,812	4,764	.....	(e)190,000	1,918	.....	15,767	487,177	.....
1916....	24,362	11,343	(h) 22,000	(b)173,343	2,076	.....	12,775	540,892	.....
1917....	16,237	15,807	(h) 52,937	(g)180,000	3,174	.....	11,431	(g)527,729	.....
1918....	(g)25,000	.....	(h) 88,670	(g)170,000	.....	.....	.....	(g)499,618	.....

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.* (h) Production of pig lead in Mexico. Lead smelted from Mexican ore in the United States is not included either under Mexico or the United States.

During the world war political jurisdiction was rather generally invoked in the Allied countries to restore control of national resources and industries to citizens of a given country or its allies. This movement was particularly marked in the British Empire, wherein there now exists an extremely centralized joint political and commercial control of the zinc industry in particular, based on the large production of zinc concentrates in Australia and expected production in Burma. In Australia, Tasmania, India, and the British Isles there has been Governmental participation in the producers' and sales organizations and in the financing of power and smelting equipment. In France this movement has taken the form of "consortiums" or associations of the principal factors in each industry, recognized by the Government and made the arbiters of all questions affecting their particular industry. The consortium of the mineral industry has been perfected into the "Société Mineraux et Metaux," 154 Boulevard Haussmann, Paris. The official announcement states that this society is organized under the auspices of the French Government in order to group the French metal producers operating both at home and abroad into a coöperative association for the purchase and sale of metals and metallurgical products.

The mining and metallurgical companies participating in the society comprise the principal companies in France producing or refining metals, and also the lead, zinc, copper, iron, and smelting companies controlled by French capital in Spain, Algeria, Tunis, Mexico, and Peru. Thus there is brought about a highly centralized organization of that portion of the mining and metal industry under French control for mutual protection and advantage in competition with other nationalities. This

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development is worthy of special note by everyone interested in the mineral industry.

The present annual output of the companies participating in the Society is about 200,000 metric tons of lead.

United States Production

Figures given hereafter in the detailed reports of production by states are issued by the United States Geological Survey, some estimated from actual reports covering 10 or 11 months of the year, and the remainder are final figures. Mine production in the United States decreased very materially, total smelter production increased somewhat, but imported ore was almost entirely immediately exported as lead. Only two regions showed any material gain over 1917 figures—Joplin, Miami and environs gained 46,000,000 lb., and Montana some 15,000,000 lb. Southeastern Missouri still retains the lead of all regions in the United States with a production of 336,000,000 lb. of lead, a decrease of 60,000,000 from the record year. Idaho, who tread on her very heels in 1917, recorded an even greater loss—105,000,000 lb. Other states producing smaller amounts also registered losses: Utah 11,500,000, Colorado 4,000,000, Nevada 4,000,000, California 8,500,000, and Arizona 10,000,000.

Tabulations are appended giving the origin of all the lead produced from ore by United States smelters and refineries, the same amounts redistributed according to its variety, the statistics of imports and exports, and finally a statement of the amount of lead available for consumption in the United States. The last amount does not differ greatly from 1917, being somewhat larger, but does show an increase of over 25 per cent. above the available supply in the last year before the outbreak of hostilities. Under the circumstances it was not surprising that a curtailment even to below the figures for 1913 was put into effect with the coming of the new year.

In addition to the domestic stocks noted, the War and Navy Departments had stocks on Jan. 1, 1919, the amount of which had not been made public. At the signing of the armistice, the Government was purchasing about 25,000 tons monthly, and up to Dec. 15 there were probably no unsold stocks in the hands of smelters or refiners. Thereafter, however, the metal in their hands increased with extraordinary rapidity.

Beyond the metal recovered from ore, from 90,000 to 100,000 short tons of lead are recovered from secondary sources, such as scrap pipe, cable coverings, battery lead and sheet lead. Figures of this production are unavailable for 1918, but the United States Geological Survey reports[1] that 93,500 tons was recovered in 1917, or about 2800 tons less

[1] *Min. Res. of U. S.*, 1917, Part I, p. 318.

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than in 1916. Remelted scrap is liable to contain more or less antimony and tin, and is not ordinarily substituted for pig lead unless its origin and uniformity is proven.

PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES[1]
(Short tons) (Apportioned according to source of ore)[2]

	1910.	1911.	1912.	1913.	1914.	1915	1916.	1917.	1918.
Domestic Ore:									
Alaska	75	51	45	6	.....	358	659	.....	.....
Arizona	948	3,428	3,891	4,901	5,602	6,953	15,328	11,733	252
Arkansas	.....	15	.....	.....	52	51	170	.....	120
California	1,207	615	811	3,294	3,698	5,606	3,633	10,934	6,686
Colorado	38,542	30,442	37,039	42,840	41,198	32,352	33,046	33,995	32,150
Idaho	109,951	117,335	127,780	137,802	177,827	160,680	170,059	197,942	145,424
Illinois	263	308	513	619	427	910	670	1,439	2,273
Iowa	.....	.....	.....	.....	34	.....	.....	.....	.....
Kansas	1,308	2,522	1,937	1,504	1,043	1,320	1,737	3,025	7,252
Kentucky	50	.....	91	16	16	95	37	.....	.....
Missouri	161,659	182,203	162,610	152,430	194,275	195,634	218,253	234,156	194,175
Montana	1,943	2,484	2,517	3,256	4,386	4,853	4,961	10,976	18,568
Nevada	2,246	1,082	5,699	6,142	5,996	7,664	11,858	13,839	11,658
New Mexico	1,890	1,371	2,511	1,821	741	2,157	3,290	4,750	4,118
North Carolina	2	35	34	10	.....	.....	.....	.....	.....
Oklahoma	1,805	1,925	2,500	3,214	3,916	4,346	10,969	26,358	56,097
Oregon	.....	11	21	37	17	11	9	.....	.....
South Dakota	8	33	12	7	2	5	12	.....	.....
Tennessee	.....	.....	.....	.....	.....	8	.....	.....	.....
Texas	36	57	30	108	89	111	26	.....	.....
Utah	60,605	54,933	60,664	71,069	88,976	106,105	111,789	89,260	83,504
Virginia	87	400	85	878	143	457	740	.....	.....
Washington	339	612	53	9	2	11	217	4,895	2,636
Wisconsin	3,909	3,966	3,301	2,639	1,818	2,632	3,121	4,139	4,533
Undistributed	101	48	120	63	99	131	159	.....	.....
Zinc residues	2,237	1,987	3,131	3,765	4,125	4,567	5,478	.....	.....
Total from domestic ore	389,211	405,863	415,395	436,430	534,982	537,012	596,221	573,350	559,880
Foreign Ore:									
Africa	3,310	582	1,774	5,976	2,942	.....	328	1,738	1,519
Canada	25	122	29	16	2	1,174	1,231	1,100	7,550
Central America	3	28	.....	.....	.....	1	7	.....	.....
Mexico	11,704	7,333	7,407	4,512	2,386	5,437	1,917	7,607	4,798
South America	2,996	2,677	2,332	2,617	1,821	2,829	2,366	1,533	1,101
Other foreign	27	22	30	102	488	140	236	3,894	84
Foreign Base Bullion:									
Canada	.....	.....	.....	.....	.....	.....	1,072	6,750	8,108
Mexico	76,805	84,220	76,805	37,359	21,689	33,173	11,598	39,508	76,809
South America	.....	.....	.....	.....	.....	275	151	189	39
Total from foreign ore and base bullion.	94,870	94,984	88,377	50,582	29,328	43,029	18,906	62,319	100,008
Grand total, derived from all sources.	484,081	500,847	503,772	487,012	563,810	580,041	615,127	635,669	659,888

[1] These figures include the lead derived from scrap and junk by primary smelters.
[2] U. S. Geol. Survey, except totals for 1917 and 1918.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES (a)
(Refinery statistics. In tons of 2000 lb.)

Year.	Domestic Origin.					Foreign Origin.		Grand Total.
	Desilverised.	Antimonial.	S. E. Mo.	S. W. Mo.	Total.	Desilverised.	Antimonial.	
1913	261,616	16,345	133,203	22,312	433,476	54,774	2,300	490,550
1914	318,697	17,177	177,413	25,448	538,735	28,475	1,119	568,329
1915	305,160	24,601	185,849	20,312	535,922	43,301	2,883	582,106
1916	330,189	22,819	206,105	33,128	592,241	17,832	3,304	613,377
1917	319,015	16,265	205,861	40,575	581,716	50,962	2,991	635,669
1918	282,205	15,833	189,063	63,628	550,729	107,531	1,628	659,888

(a) From *Eng. Min. Jour.*

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IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, IN POUNDS(a)

Country from which Imported.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
United Kingdom	279,546	404,594	245,548	185,236	261,406	2,689,992	56,710
Germany	494,237	262,132	4,529,919	.....	.....	.....	.....
Other European countries.	55,356	143,293	123,085	32,537	314,353	255,907	5,800
British North America .	319,497	338,569	384,007	2,303,170	12,606,216	11,738,379	28,255,878
Mexico	159,455,664	95,693,439	46,282,207	94,247,384	48,395,670	135,782,759	162,259,199
South America	3,207,936	8,766,327	2,417,744	5,420,567	6,235,758	4,556,460	1,962,124
Other countries	3,309,365	8,685,612	2,694,293	802,516	2,845,949	5,520,323	4,705,049
Total imports.	167,121,601	114,293,966	56,676,803	102,991,410	70,659,352	156,543,820	197,214,760

(a) Bureau of Foreign and Domestic Commerce.

IMPORTS OF LEAD, BY CLASSES, IN POUNDS

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.
		Gross Weight.	Lead Content.		
1911	35,686,180	141,481,852	138,952,372	5,264,800	179,903,352
1912	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914	23,649,637	33,444,503	32,730,320	296,846	56,676,803
1915	18,185,140	86,247,995	83,986,988	819,282	102,991,410
1916	35,086,100	24,943,660	24,262,435	11,310,817	70,659,352
1917	41,292,876	107,279,997	103,664,970	11,585,974	156,543,820
1918	37,070,340	155,810,003	149,663,889	10,480,531	197,214,760

PIG LEAD EXPORTED FROM THE UNITED STATES
(Short tons)

Destination.	1916.		1917.		1918.	
	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Domestic.
Canada	37,095	983	24,103	10,189	5,680	10,140
Great Britain	8,048	2,277	13,330	13,461	45,310	21,288
Netherlands	2,553	611	140	168	.....	.....
Belgium	.....	.....	.....	.....	.....	.....
France	673	174	791	995	11	862
Italy	336	.....	731	1,210	1,574	.....
Germany	.....	.....	.....	.....	.....	.....
Russia	17,960	1,285	7,366	7,790	299	115
Japan	14,879	1,765	937	280	6,645	2,848
Other countries	19,021	2,785	6,290	3,559	4,675	1,801
	100,565	9,880	53,688	37,652	64,194	37,054

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PRIMARY REFINED LEAD AVAILABLE FOR CONSUMPTION IN THE UNITED STATES[1]
(Short tons)

	1913.	1914.	1915.	1916.	1917.	1918.
Supply:						
Stock in bonded warehouses Jan. 1	10,492	5,310	7,668	12,169	12,369	26,612
Imports—						
For consumption	11,980	7,386	9,680	12,771	78,272	96,000*
For warehouse	45,165	20,952	41,816	22,559		
Increase by liquidation	.....	.....	2,250	5,642	.....	800
Production from domestic ores	411,878	512,794	507,026	552,228	549,895	548,500
Total supply	479,515	546,442	568,440	605,369	640,536	672,000
Withdrawn:						
Exports of foreign lead—						
From warehouse	44,544	21,545	38,618	9,880	34,623	35,300
In manufactures, with benefit of drawback	9,757	9,399	3,983	5,171	7,537	2,900
Exports of domestic lead	.....	58,722	87,306	100,565	56,209	64,500
Decrease by liquidation	419	56	.....	.....	297	.....
Stock in bonded warehouses Dec. 31	5,310	7,668	12,169	12,369	26,612	30,000*
Total withdrawn	60,030	97,390	142,076	127,985	125,278	133,000
Available for consumption	419,485	449,052	426,364	477,384	515,258	540,000

*Includes lead in ore, in bullion, and as pigs, bars, and old lead.

Silver-lead Smelting Works of North America

The *Engineering and Mining Journal* gives the accompanying list of lead-smelting capacity on this continent, as of Dec. 1, 1918. "Tons of Charge" means ore plus flux, but does not include coke. The figures are

AMERICAN SILVER-LEAD SMELTING WORKS

Company.	Place.	Furnaces.	Annual Capacity(a).
American Smelters Securities Co. (Selby Works)	Selby, Calif.	3	210,000
American Smelting and Refining Co	Denver	7	510,000
American Smelting and Refining Co	Pueblo	7	380,000
American Smelting and Refining Co	Durango	4	210,000
American Smelting and Refining Co	Leadville	10	510,000
American Smelting and Refining Co	Murray	8	657,000
American Smelting and Refining Co	East Helena	4	306,000
American Smelting and Refining Co	Omaha (b)	2	82,000
American Smelting and Refining Co	Perth Amboy (b)	4	170,000
Con. Kansas City Smelting and Refining Co	El Paso	6	380,000
Bunker Hill & Sullivan Min. and Concentrating Co.	Kellogg, Ida.	3	600,000
Ohio & Colorado Smelting Co	Salida, Colo.	3	200,000
United States Smelting, Refining and Mining Co.	Midvale, Utah	7	530,000
Northport Smelting and Refining Co	Northport, Wash.	2	216,000
Pennsylvania Smelting Co	Carnegie, Penn.	2	60,000
International Smelting Co	Tooele, Utah	5	500,000
Totals, United States	.....	77	5,521,000
American Smelting and Refining Co	Monterrey	7	410,000
American Smelting and Refining Co	Aguascalientes	1	40,000
American Smelting and Refining Co	Chihuahua	7	400,000
American Smelters Securities Co	Velardeña	3	150,000
Compañia de Mineralca y Metales	Cerralvo	2	35,000
Compañia de Minerales y Metales	Guadalupe, N. L.	1	70,000
Compañia Fundidora y Afinadora de Monterrey	Monterrey	4	210,000
Compañia Metalurgica Mexicana	San Luis Potosi	10	250,000
Compañia Metalurgica de Torreon	Torreon	9	350,000
Compañia Minera de Peñoles	Mapimi	6	350,000
Masapil Copper Co	Saltillo, Coah.	1	36,000
Totals, Mexico	.....	51	2,301,000
Consolidated Mining and Smelting Co	Trail, B. C.	4	98,680

(a) Tons of charge. (b) Smelt chiefly refinery intermediates. [1] U. S. Geol. Surv.

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largely drawn from official communications of the respective companies; estimated capacities are more or less uncertain, depending upon many market and metallurgical conditions, and should be regarded as approximations. More or less of the capacity given represents furnaces which are idle owing to lack of ore, lack of market for the product, or down for repairs.

White Lead and Oxides in 1918[1]

The decline in the price of pig lead during the last 3 months of 1917 was so clearly not justified by actual trade conditions that manufacturers made no reduction on dry pigments after Oct. 19 of that year, and the prices then established continued in force until May 28, 1918.

Dry white lead opened at 9 cts. per lb. in a large way, but, following the upward course of pig lead, advanced ¼ ct. on May 28, and there were further advances of ¼ ct. on June 21 and ½ ct. on July 24, making the price 10 cts., which continued in force until the close of 1918.

For many years the margin allowed large dealers in white lead in oil had been ¼ ct. per lb., and though this was accepted as reasonable on a staple of this class when the list price ranged at 7 cts. or under, it became unprofitably small when the price reached 12 cts. or more, and corroders, therefore, adopted a system of pricing which gave to all classes of dealers a more liberal profit, based on percentages instead of upon a specified rate per pound. The schedule adopted Apr. 26 established a base price of 12¼ cts. per lb. for 100-lb. packages, with a discount of 10 per cent. on quantities of 500 to 2000 lb.; 10 and 2½ per cent. on 2000 to 10,000 lb.; 10 and 5 per cent. on 10,000 to 30,000 lb., and 10 and 6 per cent. on 30,000 lb. or over. This made the minimum price to largest buyers 10.36 cts. against 10¾ cts. as the opening price under the old system. There were subsequent advances in May, June, and July, which brought the base price to 14 cts. on July 28, giving a net price of 11.84 cts. to largest buyers, or practically 1 ct. above the opening price of the year, although pig lead had meantime advanced 1.80 cts. It is expected that future fluctuations will apply only to the base price, leaving the scale of discounts unchanged.

Sales of dry white lead to paint manufacturers, and of lead in oil to painters, were considerably below any previous year for a long period, owing chiefly to the effect which war conditions had in restricting building operations everywhere. There was little new work except Government construction, and the difficulty in obtaining labor, as well as its high cost, added to that of lead and linseed oil, caused a neglect of old work which would have been repainted under normal conditions.

The demand for oxides has been large. The Government required the use of enormous quantities of red lead on ships and other structures,

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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and the industries using red lead and litharge have all been large consumers, so that sales of these products have been fully equal to the average of previous years going back to pre-war dates. Price fluctuations have synchronized with those of white lead, and at the close of 1918 the minimum quotations for casks to largest buyers were 11¼ cts. per lb. for red lead and 10¾ cts. per lb. for litharge.

Linseed-oil prices in 1918 established an entirely new record for a period of at least 60 years. Starting at about $1.30 per gal. in jobbing quantities, the price advanced steadily until $1.90 was reached in August. During the last 3 months of 1918 the price receded somewhat as new-crop flaxseed became available, but, at the close, $1.58 was quoted, and the average for the year will be about that figure. This has added so much to the cost of paint that property owners have deferred painting, wherever it could be postponed.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1902...	11,669	$1,262,712	114,658	$11,978,172	12,755	$1,299,443	867	$138,349
1903...	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000
1904...	13,938	1,672,569	126,336	13,896,913	12,487	1,248,691	1,125	168,681
1905...	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
1906...	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
1907...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
1910 (b)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,335
1911 (b)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
1912 (b)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,240
1913 (b)	17,635	2,127,976	142,626	18,112,219	23,093	2,524,707	434	71,625
1914 (b)	18,697	2,151,054	159,474	19,943,239	27,345	2,856,092	426	70,019
1915 (b)	19,435	2,397,900	156,101	19,393,691	26,118	2,822,415	.....	.....
1916 (b)	23,035	3,933,566	128,979	21,274,480	37,739	5,853,543	(c)	(c)
1917 (b)	25,478	5,525,018	115,200	22,529,831	44,102	8,611,074	(c)	(c)

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included in 1904–1910. (b) U. S. Geol. Surv. (c) Orange mineral included in red lead.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1903.....	1,152,715	$40,846	453,284	$24,595	42,756	$1,464	756,742	$36,407
1904.....	836,077	30,115	587,383	33,788	44,541	1,500	766,469	37,178
1905.....	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
1906.....	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
1907.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
1910.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1911.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
1912.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
1913.....	99,832	4,903	672,109	45,266	34,023	1,750	330,525	22,205
1914.....	13,554	2,907	596,567	40,213	33,651	1,805	240,388	16,388
1915.....	1,968	142	239,187	24,608	20,650	1,422	171,572	14,061
1916	20,467	5,302	88,617	8,050	1,320	150	70,934	8,781
1917.....	50	13	20,238	1,965	*Nil.*	*Nil.*	33,294	4,892
1918.....	5	1	158	131	100	12	*Nil.*	*Nil.*

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Lead Products Other than White Lead[1]

It is significant to note the dissimilarity between the normal demand and that created by the war. A lead shortage which occasioned "rationing" for the greater part of the year makes it probable that the bulk of the lead was consumed in the so-called "essential" industries in volume greatly in excess of the ordinary peace-time consumption.

Babbitts, solders, casting metals, and alloys of lead, tin and antimony were very strong during the year, being largely used in transportation, machine tools and shops generally. The total production probably equaled that of the peak year 1917.

Exports of red lead and litharge were embargoed for some time in order to conserve the quantity of metal available in the United States. However, the amount of these oxides which were consumed by the glass and rubber manufacturing interests was probably larger than in 1917.

Manufacturing of loaded shot-gun shells practically ceased in the United States owing to the high price of the shells, and also owing to the fact that the industry was looked upon as non-essential. Consequently the amount of lead consumed in shot will be found to be lower than any year since adequate records were kept.

Lead pipe was influenced by contradictory forces. Building construction, which ordinarily consumes the bulk of the production, was sharply curtailed, being confined to necessary plants and housing for war workers. On the other hand, a new demand from chemical plants and the shipbuilding industry did much to maintain the output at a point close to the average.

Government demand for shipbuilding, acid and powder plants, together with the manufacture of lead discs for high-explosive shell, taxed the capacity of manufacturers of lead sheet. However, the overexpansion of the acid and powder plants will undoubtedly be felt for many years in the lessened demand for sheet-lead products.

A large tonnage of an alloy composed of 87.5 per cent. lead and 12.5 per cent. antimony found its way into shrapnel bullets. The consumption of lead for this purpose was twice as large as during 1917, and probably totals as much as 75,000 tons since the war started.

The Lead Market

Early in 1918 the market showed strong signs of recovery from the severe depression experienced late in 1917. Freight congestion aided materially in a strong demand and higher prices for spot metal, the price

[1] J. R. Wettstein, *Eng. Min. Jour.*, 107, 54, Jan. 11, 1919.

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advancing from 6¾ to 7 cts. by the middle of January. Railway deliveries became a little better in February, even though the time in transit had been increased to two months, and the February market closed with a strong domestic and foreign demand at 7¼ cents. In the face of a strong position, there were intimations that the War Industries Board would prevent a runaway market, and the purchasers consequently withdrew from the market, with the result that April closed at 6½ cents. By the middle of June, however, there was no doubt that there would be a stringency in lead, and at the request of the War Industries Board, a lead producers' committee under the chairmanship of Clinton H. Crane was organized to take care of the business, and proceeded to keep the price not above 7¾ cts., New York. A modification, however, became necessary in July, compensating the increase in freight rates, and the price of 8.05 cts., New York, prevailed until Dec. 20. The producers put their metal into the hands of this committee, which pro-rated the supply among the purchasers according to their needs and uses.

With the signing of the armistice, the lead producers found themselves in relatively good shape, with many unfilled orders, and some old average-price contracts. Cancelations, and lack of new buying caused a serious accumulation which was met by a curtailment of smelting capacity in all cases except one, which fact caused the abandonment of the producers' committee, and an open market on Dec. 20. Reductions of ¼ ct. per day for tonnage lots failed to bring much business, and at the end of the year there were signs that the market might rally at 5½ cents.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK (a)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1904...	4.347	4.375	4.475	4.475	4.423	4.196	4.192	4.111	4.200	4.200	4.200	4.600	4.309
1905...	4.552	4.450	4.470	4.500	4.500	4.500	4.524	4.665	4.850	4.850	5.200	5.422	4.707
1906...	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907...	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908...	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909...	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910..	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911..	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.426
1912..	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913..	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370
1914..	4.111	4.048	3.970	3.810	3.900	3.900	3.891	3.875	3.828	3.528	3.683	3.800	3.862
1915..	3.729	3.827	4.053	4.221	4.274	5.932	5.659	4.656	4.610	4.600	5.155	5.355	4.673
1916..	5.921	6.246	7.136	7.630	7.463	6.936	6.352	6.244	6.810	7.000	7.042	7.513	6.858
1917..	7.626	8.636	9.199	9.288	10.207	11.171	10.710	10.594	8.680	6.710	6.249	6.374	8.787
1918..	6.782	6.973	7.201	6.772	6.818	7.611	8.033	8.050	8.050	8.050	8.050	6.564	7.413

(a) From *Eng. Min. Jour.*

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AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON (*a*)
(In pounds sterling)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904....	11.558	11.592	12.037	12.254	11.754	11.521	11.667	11.737	11.787	12.187	12.892	12.775	11.983
1905....	12.875	12.462	12.296	12.658	12.762	13.000	13.608	13.958	13.950	14.679	15.337	17.050	13.719
1906....	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743
1914....	19.665	19.606	19.651	18.225	18.503	19.411	19.051	(*b*)	(*b*)	(*b*)	18.500	19.097	.....
1915....	18.606	19.122	21.883	21.094	20.347	25.170	24.611	21.946	23.151	23.994	26.278	28.807	22.917
1916....	31.167	31.988	34.440	34.368	32.967	31.011	28.137	29.734	30.786	30.716	30.500	30.500	31.359
1917....	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500
1918....	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	31.20	40.00	30.100

(*a*) The statistics for 1904–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main. Those for subsequent years are from the *Eng. Min. Jour.* (*b*) London exchange closed.

Cost of Producing Lead

An analysis of the cost of producing lead from the silver-lead ores tributary to the Salt Lake City smelters appeared in *Chemical and Metallurgical Engineering* for July 1, 1918, and will be of interest to one studying the effect of the recent increases in rail, commodity and labor rates prevalent during the latter months of the war.

Fifty years ago lead was cheap because it came from easily worked bonanza deposits. Since then the upward tendency due to the steady decline in grade of ore and increase in cost of labor has been counterbalanced by improvements in mining and metallurgical methods, together with decrease in freight rates. Indeed, the last item, freight, is so important to Middle Western and Western producers that it would be profitable to consider the effect of Mr. McAdoo's recent revision of rates. The increase amounts to 25 per cent. on most commodities, ranging upward on essentials like coal, coke, flux, and ore to a probable maximum of 55 per cent. on bullion. With such unexpected jumps in the price of transportation, the custom smelter who contracted several years ago to treat ore at a price based on current and expected costs at that date is left with the alternatives of negotiating for a revision of the payment schedule, shutting down, or tumbling into bankruptcy.

The purely custom smelter or refinery operates under entirely different conditions from one which treats its own ores. The latter's deficit on a rising market may easily be swallowed by the handsome profit of the producing and selling departments. The custom smelter, on the other hand, is something like a salaried man if it operates on a "cost plus" schedule; in effect it then works for the miner, being but one of a train of related industries necessary to take lead from underground and put it into the plumber's pot. The total cost of the train must not only be less than the selling price of the metal, but the miner must get a share sufficient to pay for the delivery of the ore to the smelter, who in turn must receive a portion necessary to load the pig on cars. Lastly, the refiner's income at the least must balance his cost of putting usable metal on the market.

The production of lead is a field particularly well suited to study the effects of inflated prices. For years the price has fluctuated within such narrow limits that

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mutual relations between the various parties to the production were well stabilized, and it had become almost a common saw that "4 cts. is a good price for lead." On this basis the average of 4.3 cts. for the decade ending with the war evidently provided a comfortable, perhaps more than comfortable, share for miner, smelter and refiner, with somewhat the following partition:

Mining	1.4 cts.
Smelting	1.8 cts.
Refining	1.1 cts.
Total	4.3 cts.

It will be noted in passing that these approximately correct figures correspond to conditions in those regions feeding the Colorado and Utah smelting centers. Most of these ores, of course, carry other valuable metals than lead, but the entire cost of smelting is assessed against the average lead content. This gives a fictitiously low return to the miner for his lead, but his receipts are augmented by the values of gold, silver, copper and iron. The case has thus been simplified for the argument which follows, since the wartime appreciation in market value of silver and copper has been equal to or greater than that of lead. "Mining" is thought of as including mining, development, amortization, freight and all other expenses incidental to delivering the ore to the smelter. "Smelting" includes the entire cost of recovering the base bullion, while the item "refining" covers freight on bullion and selling costs as well.

Since the war the price of everything has soared. In an inquiry in the Salt Lake region it was found that labor is receiving 50 per cent. more now, for a considerably less efficient performance. Supplies have increased 35 per cent., coal 30 per cent. and coke 50 per cent. On this basis the statement freely repeated that production costs have increased two-thirds in the last four years appears somewhat exaggerated when applied to the lead-smelting region; possibly an average increase of 50 per cent. would represent the costs ruling for the first half of 1918. Therefore, in order that the operations may now proceed as comfortably as before, the new apportionment would approximate

Mining	2.1 cts.
Smelting	2.7 cts.
Refining	1.6 cts.
Total	6.4 cts.

The market was about 6.8 cts. during this time, the surplus 0.4 cts. going generally to the miner, who thus seems to be better taken care of than his partners. Indeed, it is unquestionable that the two latter have not increased their income proportionately to their costs, since so many old contracts are still in effect. In other words the adjustment of contracts will lag far behind while the ore shipments closely hug the rising markets.

But assuming for the instant that each has revenue enough to enable him to carry on his share of the work, now comes an increase in freight rates, bad enough in itself, but scaling all prices upward to an even greater extent. Carriage on bullion alone is increased 0.3 cts. per lb. The smelter is hard hit on account of its large requirements of flux, coal and coke. The miner weeps over his ore freights. An estimated reapportionment of expense would now be

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Miner	2.1 + 0.2 = 2.3 cts.
Smelter	2.7 + 0.3 = 3.0 cts.
Refiner	1.6 + 0.4 = 2.0 cts.
Total	7.3 cts.

It is only another instance of the unending cycle: Up go wages, up go butter and eggs. This much is plain, however: producing lead on a 7-ct. market in 1918 is not as good a business proposition as on a 4-ct. market in 1914. And when the price of lead exceeds the cost of production, as it will sooner or later by the operation of natural laws or by governmental price-fixing, the three partners in the business of producing lead must mutually revise their agreements so that each can continue to perform his indispensable functions. The mining company, for instance, can easily see the folly of insisting upon the continuance of a contract which will shut down the smelter, for he evidently could find no other present outlet for his ore on the old basis. On the other hand, a smelter with a sliding-scale contract which pinches the small producer should not strangle this output, even if small.

Such an analysis is interesting in its bearings upon wholly unforeseen conditions affecting world trade. If the figures are still approximately correct, it is evident that at prices ruling at the end of the year—6 cts. or less—there was very little encouragement for Rocky-Mountain producers of low-grade lead ores to continue, unless their material contained a good quantity of silver, which latter has still maintained its high price. Consequently it was not surprising to note a very sharp curtailment of operations among mountain smelters early in 1919, due primarily to lack of ore shipments.

United States Production

Arizona.—Fortunately, the State of Arizona was practically free of labor troubles during the year, and her increase in copper, silver and gold was maintained or increased. However, only about half the amount of lead was produced as during the former year, decreasing from 23,465,445 lb. in 1917 to only 12,503,689 lb. in 1918, with a corresponding drop in selling price from $2,000,000 to about $985,000. One of the main reasons for the decrease was the idleness of Tennessee mine, in Mohave County. As there were very few shipments of zinc ore or lead-zinc ore, the lead recovered from residues was also considerably less. Most of the recorded production came from the Copper Queen and the Shattuck-Arizona properties in Cochise County.

Arkansas.—Arkansas produced approximately 240,000 lb. of lead from small operations in the northwestern part.

California.—The mine output of lead in California in 1917 was 21,868,626 lb., valued at $1,880,702; the final yield for 1918 is 13,372,057 lb., valued at $949,416, a decrease in quantity of 8,496,571 lb. and $931,286 in selling price. Lack of sufficient labor and the high costs of

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mining caused a curtailment of operations during the year. There were no new developments of note, the lead coming mainly from lead-silver-zinc ores in Inyo and San Bernardino counties, as in the past.

Colorado.—Colorado's output, while somewhat less than in 1917, still was maintained at a point close to the average for the last 10 years. Production in 1918 amounted to approximately 64,300,000 lb. as compared with 67,990,000 lb. in 1917. The decrease of 3,500,000 lb., with a corresponding decrease in value of slightly over a million dollars, was due to a decrease in the amount of lead concentrates shipped from the treatment of lead-zinc ores.

American Smelting & Refining Co. plants at Denver (Globe), Pueblo, Durango and Leadville (Arkansas Valley), as well as the plant of the American Metal Co. at Salida, all operated steadily, with an actual increase in tonnage from Colorado mines, but a decrease in tonnage from outside states. This was partially due to the fact that the construction of the new Bunker Hill smelter provided a near outlet for important Idaho tonnages, and partially to the fact that much less zinc-residue was returned from the zinc smelters in the Kansas-Oklahoma gas belt. Further curtailment of Colorado lead-smelting capacity is threatened by the recent shipments from the San Juan region to plants near Salt Lake City. Considerable concern has been expressed in the region tributary to the Globe plant at Denver over the intention announced by the American Smelting & Refining Co. shortly after the close of 1918, that it was their intention to close this old plant, combining all their operations at the Pueblo plant, as far as possible. Such a course is justified in view of the general obsolescence of the historic Globe smelter, while the Pueblo plant alone is capable of handling a tonnage considerably higher than has been offered within recent months. The United States Zinc Co.'s magnetic wet-concentration mill at Pueblo, treating lead-zinc sulphide ores from the Western States, was not as actively operated as in 1917.

The River Smelting and Refining Co.'s plant at Florence continued to treat low-grade zinc-lead-copper ores from Colorado and other Western states, and finally achieved a commercial success with their rather unique process. This company, which is a subsidiary of the National Lead Co., built a new plant in Florence during the latter part of 1915,[1] wherein charges of complex sulphide ores containing 20 per cent. zinc, 5 per cent. iron, 1 per cent. copper, and 7 oz. silver were smelted in a blast furnace, operating with a high percentage of coke and with a strongly oxidizing atmosphere. Slags contained 7 per cent. zinc and were relatively low in lead, copper and silver; the bulk of the precious

[1] H. O. Hofman, "Metallurgy of Lead," p. 135.

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metals were collected in a matte. The balance of the zinc with more or less lead compounds, together with a proportionate amount of silver, were volatilized and recovered as a fume, which was shipped to Keokuk, Iowa, where it was taken into solution with sulphuric acid, the zinc recovered by electro-deposition by usual methods, and the insoluble residues and precipitates resmelted for lead and silver. Recently, however, owing to the high cost of the excess amount of coke needed for this smelting, a reverberatory furnace has been built and has been successfully operated for some time. Crushed ore is rough-roasted, then mixed with coal and smelted in the reverberatory to matte and slag, large quantities of lead and zinc being volatilized, collected and treated as described above.

In response to a popular demand which has been rather insistent in some parts of Colorado for several years, the General Assembly authorized a Smelter and Ore Sales Investigation to inquire into the buying, selling and treatment of ores and concentrates. The report[1] of this committee was made public early in 1918, and covers operations of all classes of metallurgical plants in Colorado for the 5 years from January, 1912, to December, 1916.

Lake County (Leadville) showed a large increase in mine production, amounting to 23,700,000 lb. as compared with 18,586,167 lb. in 1917. Lead carbonate continued to be shipped from the Downtown district, which was unwatered in 1916. Considerable sulphide ores were shipped from the Freyer Hill district, also unwatered in 1916, but the United States Smelting, Refining & Mining Co. abandoned their operations in June. The year saw the close of the Moyer-Tucson mines of the Iron Silver Co., which had, however, purchased additional producing ground. Cessation of pumping at the Moyer added to the water at the Cord winze of the Yak Co., so that with increased costs of mining and other difficulties this property was not producing at its usual rate.

In the San Juan region the situation as to labor, mining costs, and influenza was particularly arduous, but despite these difficulties the total mineral production was reduced less than would be expected. A total reduction in lead of one million pounds below the 1917 output is recorded. San Miguel County mills, treating ore from both San Miguel and Ouray counties, produced 6,000,000 lb. of lead. Ouray County mines as operated from the Ouray side showed an increase in all metals owing to the work at Red Mountain and Sneffels. La Plata County mines were practically idle, the production being only nominal. Dolores County (Rico) showed an appreciable decrease in lead, as was also the case in Mineral County (Creede).

[1] *Met. Chem. Eng.*, **18**, 365 (1918).

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Clear Creek County's lead yield decreased 1,000,000 pounds. Despite the apparent idleness of most of the mines and the almost complete idleness of all mills in Gilpin County, the yield was approximately 60 per cent. of the 1917 production. Early in the year the Chamberlain samplers in Black Hawk and Georgetown were dismantled, and in October the plant at Idaho Springs was closed, but another company remodeled one of the idle sampling plants at Idaho Springs and began receiving ores in November. Chaffee County production showed a decrease. Pitkin County (Aspen) yielded 11,600,000 lb. of lead.

Idaho.—A serious slump in the metal output of Idaho was caused not by any lack of abundant ore reserves, but an extreme shortage and poor quality of available labor. According to the estimate contained in the promptly issued report of the State Mine Inspector, R. N. Bell, the lead output of the State for 1918 was 290,848,425 lb., as compared with the 1917 production of 395,883,000 pounds. The Coeur d'Alene district produced 90 per cent. of this amount, as can be seen from the attached table.

Blaine County	2,725,000
Bonner County	190,000
Boundary County	7,494,000
Butte County	436,000
Custer County	2,200,000
Lemhi County	4,744,000
Shoshone County	273,059,425
Total for 1918	290,848,425

The State Mine Inspector also reports the following lead production for Idaho since 1898:

1898	122,479,275
1899	86,499,506
1900	96,425,500
1901	65,967,000
1902	119,223,000
1903	220,857,956
1904	226,261,728
1905	260,791,456
1906	255,966,083
1907	234,404,920
1908	207,998,499
1909	217,594,679
1910	239,144,570
1911	274,492,873
1912	296,054,813
1913	318,377,280
1914	345,334,106
1915	369,242,000
1916	366,594,000
1917	395,883,000
1918	290,848,425

From this table it is seen that the production of last year was lower than any year since 1911.

Less than the usual amount of development work has been done in the big mines since the beginning of the great war.[1] It is especially fortunate that their orebodies show undiminished volume at the addi-

[1] "20th Annual Report of the Mining Industry of Idaho." R. N. Bell, State Mine Inspector.

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tional depth attained during that time. For instance, in the Bunker Hill and Sullivan, the largest mine in the State, the most recent work on a point 4600 ft. on the dip of the vein shows the main ore channels to be normal as to position and character. Hecla, at Burke, is making the best showing in its history at its deepest levels, while the Hercules at 2800 still displays large stope faces in galena. One of the more recently developed mines, the Tamarack and Custer Consolidated, is now at a depth of 1200 ft., and is working on a trunk channel 40 ft. wide and 1400 ft. long.

The net profits of mining companies operating in the Coeur d'Alene region in 1918 were $7,272,475, according to reports filed with the auditor of Shoshone County. First place is occupied by the Hecla with $1,984,920, second by the Hercules with $1,915,766, and third by the Bunker Hill & Sullivan with $1,379,318. The total value of the production by 14 companies was $24,093,203 and the total extraction by 13 companies was 4,447,120 tons. The only deficit is shown in the report of the Mace mine of the Federal company, which lost $5587.

For the first time since 1898 incipient labor troubles developed in the Coeur d'Alene. Early in August the Morning and Gold Hunter mines were practically suspended while some 250 men, mostly mining under contract rates and making from $6.00 to $11.00 per day, struck without notice. The matter was quickly adjusted with the aid of Government officials by the institution of two pay-days a month and the elimination of the short-change day, the men abandoning their demand of being hauled to and from work on company time. The relations between miners and operating companies in this region has been remarkably friendly ever since the vicious outbreaks of the late nineties, due in great measure to the attitude of the large operators.

Boundary County's production of over 7 million pounds is nearly all due to the Idaho Continental mine. Here a limited amount of development work has revealed the fact that three supposedly separate shoots were really one persistent channel nearly a mile long. This mine is situated 26 miles from the railroad at Porthill, near the Canadian line; its outlet is by means of motor trucks operating over a roadbed constructed on a maximum grade of 4 per cent., built in anticipation of a future railroad.

The North Star Mine in the Wood River District, Blaine County, had a great deal of difficulty in getting satisfactory results from their 150-ton mill. Their ore is a zinc-lead complex containing arsenical iron sulphide and some antimony. After considerable experimentation they were able to operate continuously, getting a 40-per cent. zinc con-

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centrate, but in September the slump in the market for that metal caused all operations to be suspended. The same company operates the near-by Independence mine, whose ore consists of quartz with coarsely crystalline galena and little pyrite or sphalerite. A rather small mill has restricted its daily output to 25 tons of concentrates and high-grade ore, the latter carrying 30 to 50 per cent. lead.

Custer County produced ore largely from the Red Bird mine near Clayton, which is operated by a small crew of local leasers. The United States Smelting, Refining & Mining Co. is developing the Keenan-Kennedy and Horseshoe mines at Mackay. This property carries large contact deposits of lead-silver ore high in iron, which would be valuable fluxing ore for silicious charges.

Butte County shows a very small production, largely due to the fact that the Wilbert mine on Little Lost River was practically a non-producer owing to a fire which destroyed their mill. This company is sinking a new shaft and installing new surface equipment, and since the ore showing on its bottom level is the best so far found it should be confidently expected to resume larger production with a turn in the market.

Leasers operated throughout the year at the Pittsburgh-Idaho mine, in the Gilmore district, Lemhi County, making good recoveries from old fills. The owning company has finished a new incline shaft to the 700-ft. level, and has installed a modern power plant, driven by Diesel engines. Their ore is completely oxidized at the lowest levels yet attained. Twenty miles further north, near Leadore, the Sunset Mining Co. continued their development on a very interesting body of gray carbonate.

Illinois.—The shipments of silver-bearing galena concentrates from the southern Illinois fluorspar region amounted to 1228 tons, 32 tons more than in 1917. The production of galena concentrates by mines in northern Illinois increased from 788 tons in 1917 to 1868 tons in 1918. The recoverable lead content of galena concentrates from Illinois in 1918 amounted to 2273 tons, valued at $322,766, compared with 1439 tons, valued at $247,508 in 1917. The Marsdon-Black Jack mine, of the Mineral Point Zinc Co., was the largest producer in the northern Illinois district. The only other large producing lead and zinc mines were the North Unity and Graham mines, of the Vinegar Hill Zinc Co.

Kansas.—Southeastern Kansas produced about 18,166,000 lb. of lead concentrates, which contained 14,504,000 lb. of lead, a gain of 8,454,000 lb. As was clearly indicated in 1917, the new mining district, Blue Mound-Baxter Springs, which is the northerly extension of the Miami field into Kansas, made a greatly increased output in 1918. This output,

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however, was not so large as had been expected, for many of the new properties were not developed as rapidly as they might have been. Many new shafts were sunk and some new mills were erected, but very few properties were operated at capacity. The proved area of the district was extended toward the north and northwest, and new mines were opened near Baxter Springs and north of Hockerville. The production of the Blue Mound-Baxter Springs area increased from 1005 tons of galena and 12,070 tons of sphalerite in 1917 to 7625 tons of galena and 40,473 tons of sphalerite in 1918. This district, from which the first shipments were made in 1917, yielded 84 per cent. of the galena and 72 per cent. of the sphalerite shipped from mines in Kansas in 1918. The larger producing mines were the Blue Mound, Blue Diamond, Barr, Webber, Southern, Early Bird, Naylor, Silver Fox, Kansouri, Kanoma, and Redskin, west of Blue Mound; and the Lucky O. K., Queen Esther, Kansas Line, Lucky Jennie, and others, east of Blue Mound. Mining conditions are somewhat similar to those in the Joplin District, and are discussed at more length in the chapter on Zinc.

Missouri. Southeastern District.[1]—Flat River and environs produced about 336,000,000 lb. of pig lead in 1918, with an approximate value of $25,000,000, for the first time in over 50 years failing to show a substantial increase over its former annual outputs. High prices of lead were responsible for the peak production of 396,000,000 lb. during 1917, and while the average prices during 1918 were what formerly would have been considered high, the district, though prosperous, was unable to build up a huge profit owing to the general increase in cost of labor and all commodities. Curtailment of operations following the signing of the armistice resulted in operating only 5-day weeks during the month of December, a program which was shortly later reduced to 60-per cent. operation owing to the continual accumulation of unsold lead.

St. Francois County is responsible for almost the entire output, since in the neighboring Madison County, where granite and porphyry occur in close proximity to the lead orebodies, the output of mixed sulphide ores was much below normal. Surface diggers from the gopher mines in Washington, Jefferson and Franklin counties flocked to the big mines to enjoy the high wages, with a corresponding influence on the output from these regions. The St. Joseph Lead Co. maintains its lead among the producers, mining 2,299,490 tons of ore which were treated in the mills at Bonne Terre, Leadwood and Elvins, producing 133,099 ton of concentrate, 125,320 tons of which was shipped to the company's smelter at Herculaneum and from which was produced 79,620 tons of

[1] "The Southeastern Missouri Lead District." H. A. Wheeler, *Eng. Min. Jour.*, 107, 132, Jan. 11, 1919.

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pig lead. This company's oldest mill—at Bonne Terre—has been in existence since 1883, the first building being still in use. As a matter of fact, however, the problem of tailings disposal has only recently been pressing owing to the fact that large quantities of these so-called "chats" have been shipped to St. Louis for railroad ballast and concrete aggregate. The surplus has, however, gradually filled up all the available dumping areas, and a tailings stacker similar to the ones in use at other mills in the district has been erected. All the fine tailings and slimes have been settled in an artificial reservoir made of a high dam of coarse "chats," through which the surplus water filters perfectly clear. A second pond covering over 70 acres is now under construction, anticipating the filling of the original area.

The Federal Lead Co. mined ore throughout the year from five shafts, concentrating the material in the older No. 3 mill of 4000 tons capacity, and their new No. 4 mill of 3000 tons capacity. A department for filtration and drying of flotation concentrates was installed in the No. 3 mill. Underground, the most notable improvement consisted in the successful adaptation of the Keystone shoveling machine, three of which are in operation, effecting a marked saving of labor. As high as 250 tons per shift has been handled by a single machine.

The National Lead Co. maintained its previous output in spite of labor shortage. Its 3000-ton mill handled their own production and the Baker Lead Co.'s output as well, shipping the concentrates to the smelter in Collinsville, Ill. The Desloge Lead Co. was badly handicapped by a shortage of men through army draft and influenza.

The historic Mine La Motte was closed down in 1918, in the midst of an attempt to steam-shovel some 150 ft. of overburden from the orebody. A huge rock-breaker and very modern picking plant had been installed to handle everything removed by the shovels, wherein boulders were to be crushed to fist-size, and the lead-bearing and barren rock was to be picked out as the broken material was conveyed along short traveling belts. Entrained clay from the outcropping was then washed to recover some carbonate and sulphide of lead, but this operation resulted in a very low-grade product, mainly sand carrying 5 to 8 per cent. of lead. Eventually it was planned to concentrate the entire vein stuff and old pillars from the underground system which has been worked at intervals for centuries.

The total mine production of lead in Missouri is given by the U. S. Geological Survey as 194,175 short tons, compared with 234,156 tons in 1917.

Montana.—Recent production of lead in Montana has shown a steady increase. For a number of years prior to 1913 the output fluctuated

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about the 4,000,000-lb. mark. Since that time its increase is best seen from the following list:

	Pounds.
1913	6,512,000
1914	8,772,000
1915	9,706,000
1916	13,595,135
1917	21,951,220
1918	37,135,875

A corresponding increase in value to about $2,668,000 is recorded. A large part of this increase has come from various properties in Butte, notably the workings of the Anaconda Copper Mining Co. Zinc ore shipped to their electrolytic refinery in Great Falls contains a considerable quantity of lead; this remains in the insoluble residue from the leaching tanks, and is either smelted to a leady matte in a reverberatory furnace, or else shipped to the International Smelting Co.'s smelter at Tooele, Utah, for treatment in their lead blast furnaces. Conversion of lead-bearing matte produces a fume rich in lead, which is bag-housed, and the values recovered by resmelting to bullion. Butte and Superior is also a notable contributor, 468,814 tons of ore being milled, producing 2790 tons of lead concentrates containing about 40 per cent. lead. From the same ore about 135,543 tons of zinc concentrates, containing 51 per cent. of zinc and 3.6 per cent. of lead was produced, this amounting to 9,650,000 lb. of lead. Such material is shipped to zinc retorts in the Oklahoma gas belt, and the residues returned to a lead smelter for resmelting. The Snow Storm mine at Troy, Lincoln County, was also a notable contributor. Small producers in Jefferson County—such as the Angelica and Pilgrim mines—in Meagher, and in Lewis and Clarke counties produced their accustomed quotas.

Nevada.—The mine output of lead decreased from 27,677,928 lb. in 1917 to only 23,316,534 lb. in 1918. The value of the output decreased from $2,380,302 to about $1,655,000. One of the largest lead producers in the State was the Prince Consolidated, at Pioche, which shipped iron-manganese ore containing gold, silver, and lead. From the Yellow Pine district of Clark County considerable high-grade lead ore was shipped, some lead product was separated from a lead-zinc ore, and considerable lead-zinc ore was shipped to the zinc smelters or oxide plants. Considerable lead was produced by the Combined Metals, at Pioche; the Groom mine, in Lincoln County; and several properties at Eureka.

New Mexico.—The output of the mines of New Mexico amounted to approximately 8,235,000 lb. of lead, in comparison with 9,501,000 lb. in 1917, a decrease of 1,266,000. Lead ores were shipped from the Central

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and Steeplerock districts, Grant County, and the Cooks Peak and Victoria districts, Luna County. Considerable quantities of lead carbonate and lead-zinc carbonate ores continued to be shipped from Kelly, Socorro County, and during a part of the year lead ores were shipped from the Organ Mountains, Dona Ana County. The small lead smelter at Deming, destroyed by fire in October, 1917, has not been rebuilt.

Oklahoma.—Miami and its environs produced in the neighborhood of 110,000,000 lb. of lead as a by-product from their major operation of zinc-mining. Although the presence of ore in these regions has been known since 1894, intensive mining did not commence until 1916, expanding into the aspects of a dozen simultaneous booms during 1917 and 1918, and drawing most of the population and activities from the older camps to the north and northeast. Mills and towns sprung up on every side, towns which jump at you as out of a Brete Harte story book, towns where they do not have time to put in a culvert and fill a deep gulley crossing the main (and only) street.

The lead production of the State jumped from 26,358 short tons in 1917 to 56,097 tons in 1918, according to the U. S. Geological Survey figures.

Utah.[1]—Mining labor was scarce and inefficient in Utah during 1918, which, combined with an influenza epidemic, increased wages, higher freight rates and smelter schedules, made general operating conditions abnormal. Lead production was fair, however, during the first 9 months of the year. The increase in freight rates and its accompanying effect on smelter schedules during the middle of the year caused curtailment of the higher-cost producers, and a stoppage of low-grade ore shipments. Previous to that time production had been maintained at the 1917 pace, though modified by winter hauling conditions. During the summer and fall, as noted above, there was a continuous decrease in the amount of dump ores, and of shipments from small producers and lessees. For these reasons the mine output of lead decreased from 178,520,958 lb. in 1917, valued at $15,352,888, to 167,008,224 lb. with a value of $11,857,584 in 1918. The lead smelting plants at Murray, Midvale and Tooele were operated continuously on both Utah and custom ores, but they were not run at full capacity during the entire year.

The increase in freight rates was particularly felt by the lead producers. On July 25 all class and commodity rates were increased 25 per cent., with a heavy flat increase on base bullion; the rates on ore to Valley smelters took a maximum increase of $3.03 per ton on $300 ore. The new schedule also applied a 30-ct. flat increase on iron ores shipped for fluxing. The increase on bullion from smelters to the East was

[1] "Mining in Utah in 1918." E. R. Zalinski, *Eng. Min. Jour.*, Jan. 25, 1919.

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$6.50 per ton, an advance of 65 per cent., making a freight rate of $16.50 per ton of base bullion.

About 90,000 tons of miscellaneous ores and concentrates were shipped from Park City, the most prominent producers being the Silver King Coalition, Judge Mining & Smelting, Daly West, Ontario and the Silver King Consolidated. A 150-ton flotation mill was erected by the last named in Thayne's canyon for silver, lead and zinc ores. Altogether a large decrease in lead is noted from this camp, only about 24,000,000 lb. having been produced. Some 39,000 tons of ore was shipped from the Big Cottonwood, Little Cottonwood, and American Fork districts, against a total of 51,813 tons in 1917. About 250 miners are employed at Alta, including those at the Cardiff, and the output is principally silver-lead and copper-silver ores. An appreciable increase in tonnage was established in this particular locality. The Little Cottonwood Transportation Co. completed an 8-mile narrow-gage railroad into the camp, having a capacity of about 175 tons of ore per day. Favorable developments underground are reported from the Wasatch Mines, the Alta Consolidated, and the Cardiff.

Beaver County producers shipped a large amount of low-grade concentrates from the tailings at the Horn Silver, while a little smelting ore was produced by the old mine itself. Other shipments were made by the Red Warrior, and Wild Bill. Construction of a 100-ton mill was commenced by the Western Utah Copper Co., at Deep Creek, Tooele County, which paid its first dividend, and by the Utah Mine, and Fish Springs, about 30 miles south.

Good shipments of silver-lead ore were made from the Tintic district, (especially during the early part of the year), from the Iron Blossom, Chief, Gemini, Ridge and Valley, Eagle and Blue Bell, Victoria and Mammoth.

The Utah-Apex at Bingham was by far the largest lead producer in the State. Other lead producers in the canyon are the Utah Consolidated, the United States Mining, Utah Metal and Tunnel, and the Bingham Mines (Dalton and Lark). The United States company ships its ore to Midvale, where it is milled before smelting, the lead and zinc being separated by the Huff electrostatic process.

Nearly every camp in the State shipped some ores carrying lead and silver. For instance, the Deer Trail at Marysvale completed and operated its 100-ton flotation and cyanide mill for treatment of gold-silver-lead ore.

Washington.—The mine output of lead decreased from 9,789,687 lb. in 1917 to only 5,271,815 lb. in 1918. Most of this product came from the Electric Point property, near Northport in Stevens County, which

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company, by the way, has the distinction of being the only dividend-paying mine in the State. Production at this place was materially increased in the latter part of the year on the completion of an aerial tramway, which supplanted a difficult and expensive wagon-haul. The lead plant at Northport, serving ores from the Coeur d'Alene principally, operated throughout the year, although at reduced capacity for part of the time.

Wisconsin.—The lead concentrates sold increased from 5544 short tons, valued at $532,581, in 1917, to 6210 tons, valued at $501,901, in 1918. The lead content was 4139 tons in 1917 and 4533 tons in 1918. More than one-half of the output of lead in 1918 came from mines in the Benton-New Diggings district, and a large part of the remainder came from mines in the Shullsburg, Livingston, and Linden districts.

Lead in Foreign Countries

Australia.[1]—The first half of 1918 showed an increased output of lead as compared with the preceding 6 months, which was hampered largely by labor troubles. Figures for the year are approximately 160,000 metric tons for 1917 and 175,000 metric tons for 1918. The greater part of the total production comes from Broken Hill, and these concentrates are treated in the two smelters at Port Pirie (Associated Smelters), and Cockle Creek (Sulphide Corporation). Northampton, West Australia, some 200 miles north of Perth on the west coast, was also an active producer, supplying the Freemantle smelter with ore. New lead plants in connection with the Hercules-Roseberry mines in Tasmania are projected by the Mt. Lyell Co., from which region a future large output may be expected.

Broken Hill milled about 410,000 tons of ore and 222,000 tons of sands during the first half of 1918, producing about 106,000 tons of lead concentrates. Their present milling methods are the outcome of many years' experience, and consist of the production of four materials by wet milling: lead concentrates, zinc sands, slimes, and tailings. Zinc sands are further treated by flotation, giving both a lead and a zinc concentrate, together with a slime. Both classes of slime are again treated by selective flotation for slime-lead and slime-zinc concentrates. South Mine was the largest producer, with 19,000 tons of lead concentrates; next followed the Broken Hill Proprietary Co., with 16,300 tons. Of the nine companies in this field, all except two have flotation plants in operation, and each of these is about to complete a long-term contract with the Zinc Corporation for the treatment of current zinc sands. The mines

[1] *Eng. Min. Jour.*, Oct. 19, 1918.

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have an apparent expected life of 10 years on present reserves and outputs. Metal is disposed of by the Australian Association, which, through the Federal Government, have been able to sell all the lead to the Imperial Government. Freighting has been the chief difficulty, and there have never been enough ships to transport the soft lead made.

Northampton[1] is the oldest mineral discovery in West Australia, but active mining did not commence until the early sixties. A peak in its production occurred in 1877, when 3955 tons was shipped; low prices caused abandonment in 1891, however, not to be revived until the high prices of the last four years. Production in 1918 was approximately 5000 tons of pig lead, valued at £147,000. The area is approximately 50 miles by 25 miles in size, and is traversed by a series of basic dikes, continuous for miles, parallel to which the lodes of lead and copper have been opened, apparently true fissure veins. Narra Tarra Mine has been developed to a depth of 460 ft., and to a maximum length along the vein of 1000 ft., from which 25,000 tons of ore per annum are taken from faces varying from 5 to 20 ft. in width. This tonnage produced 3500 tons of 70-per cent. concentrates by jigs and tables. Power is supplied from gas-engines driving electric generators, the gas being had from Mond producers working on block wood. Baddera Consolidated has a similar surface plant to that just described, and ships 3000 tons of 73-per cent. lead concentrates from some 21,000 tons of ore hoisted annually. Their lode has been developed to a depth of 455 ft. and a length of 775 ft., and exhibits a width of from 4 to 16 ft. of 10.5-per cent. ore. Other producing properties are the Wheal Ellen, Wheal May, Nooka, Fortune Exploration, and Kirton's. In addition to these deposits near Northampton, the Geraldine district, forty miles further north, has recently produced about £4000 of lead per month out of new developments, opened within the year. A number of very rich veins have been worked, from 12 to 36 in. wide, which, with a little hand-picking, can be shipped as 75-per cent. ore. A great drawback to the present development of these two regions is the fact that most of the land had been acquired during the earlier mining activities, and is now held by the present owners for exorbitant royalties. Again, the freight on ore to the Freemantle smelter is 16s. 2d. per ton; it is bought on 90 per cent. of the assay, charges being 120s. per ton, so that 65-per cent. ore leaves the miners about £8 per ton for their expenses. Thus none but rich ore can be shipped, everything under 60 per cent. being stacked on the ground.

A corporation called the British-Australian Lead Manufacturers Proprietary, Ltd., with a capital of £300,000, has been formed by seven of the leading British paint manufacturers, for the manufacture of white

[1] "The Northampton Lead-Mining District," by C. M. Harris. *Min. Mag.*, March, 1919.

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lead. Works are to be erected at Launceston, Tasmania, for an initial output of 700 tons a month.

Belgium.—Official statistics show the following production during the period of the war:

	Metric Tons.
1913	53,590
1914	45,560
1915	16,770
1916	15,560
1917	22,745

The Dumont plant at Sclaigneaux was demolished by the Germans, everything of value being removed. The plant will have to be entirely reconstructed. The plants at Hoboken and Overpelt, which were German owned, of course did not suffer, but their production has been heavily decreased through scarcity of ores. These plants have now been taken over by the Belgian Government.

Bolivia.—Belated figures on Bolivian output have appeared,[1] as follows:

Year.	Metric Tons.	Official Value.
1914	1554	$155,457
1915	2121	279,989
1916	2305	460,947

All of the production exported goes to Great Britain. A little smelting is done on a small scale, but the most of the output is shipped as galena. High exchange has borne very heavily on Bolivian producers, governmental attempts to regulate the exchange value not being very efficacious.

Burma.—Burma produced 46,435,000 lb. of lead in 1918, which was distributed in the Orient. The mines of the Burma Corporation in upper Burma, India, contain some 4,000,000 tons of lead-zinc-silver ore. Recently only high-grade lead ore has been mined for smelting in the local smelter at Namtu. Construction of a 1000-ton mill was commenced near Namtu late in August, however. A rich lead concentrate can be made with jigs, a zinc concentrate on tables, while all tailings, middlings and slimes will be stored for treatment, after a satisfactory process has been developed by local experimentation, and the post-war probabilities in the metal markets have been ascertained. Eventually, a milling process somewhat similar to that at Broken Hill might be adopted, but for the time being the lead concentrate will be reduced at the present smelter with such small additions as may be desirable, any excess base bullion over refining capacity being shipped.

Canada.—Canadian production is given as 43,846,260 lb. which is worth about $4,056,000.[2] Comparison of recent years' output, together with an idea of the difficulty of arriving at a correct value for mineral

[1] *Min. Jour.*, Sept. 7, 1918.
[2] Prelim. Rept. Min. Prod. of Canada, Can. Dept. of Mines.

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production, is given in the following table, containing estimates derived in different ways.

	1916.	1917.	1918.
	Pounds.	Pounds.	Pounds.
(1) Production: Smelter recoveries from Canadian ore and recoverable lead in ore exported	41,497,615	32,576,281	43,846,260
(2) Lead contents of ores and concentrates shipped from mines in Canada	54,124,628	38,696,116	47,673,853
(3) Total production of lead bullion in Canada (including lead from imported ores)	43,100,236	41,427,304	*

* Complete smelter records not yet received.

The exports of lead in 1918 were: Lead contained in ores, concentrates, etc., 22,684,100 lb., valued at $1,321,890, and pig lead, 7,461,700 lb., valued at $668,807, as against 13,410,400 lb. of lead in ores, etc., valued at $925,056, and 1,004,500 lb. of pig lead valued at $62,453 in 1917. The heavy exports in 1917 and 1918 are partly due to the fact that a few thousand tons of base bullion was exported from Trail, B. C., for refining in the United States.

Ontario production was 1,670,251 lb., which is about the same as for the preceding year.

Quebec exported considerable ore from Notre Dame des Anges.

British Columbia produced approximately 90 per cent. of the Canadian production, this having been smelted at Trail during years past. Late in 1917 this plant placed an embargo on all lead ore having more than 4 per cent. zinc, which includes nearly the whole available tonnage. Immediate pressure was brought to bear on the Dominion Government to remove the existing embargo on lead ores, which was done. However, the greater freight rates to smelters in the United States, together with a 6-ct. lead market did not mean much relief to the Canadian situation, until early in 1918 the Trail smelter resumed the acceptance of ores on the basis of average shipments during the past 12 months, having settled meanwhile an unfortunate strike among their employees. A great deal of Canadian lead had been going into munitions, and during 1918 a strong effort was made to replace part of the 20,000 tons of manufactured lead products imported into Canada by like materials made at home of local metal.

A dormant investigation of British Columbian smelting schedules authorized by the Dominion Government, but halted by lack of funds, was revived by lead-ore shippers following an increase of 45 cts. per ton announced by the Trail smelter early in the fall. This investigation was under progress during the latter part of the year, but no report of their findings is yet available.

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ESTIMATED PRODUCTION OF LEAD IN BRITISH COLUMBIA, IN 1918, BY DISTRICTS

	Pounds.
Fort Steele	19,340,800
Slocan	11,665,700
Ainsworth	7,157,400
Windermere-Golden	3,031,000
Nelson	2,146,581
All others	608,180
Total mine production	43,949,661

The above figures show, as compared with the previous year, that the lead production in 1918 was increased in Forte Steele, Ainsworth, and Windermere-Golden districts and that there was a slight decrease in the Slocan and Nelson outputs.

France.—Previous to the war the French consumption of lead was about 108,000 tons a year, while the local output amounted to only 28,000 tons. There was thus every incentive for the development of lead smelting in France, reducing the ores produced in colonies and protectorates. Recently an important smelting works has been erected in Marseilles by the Société de Pennaroya,[1] which will especially treat Tunis ores, and the Mégrine works near Tunis has been enlarged and production pushed. French metallurgists are of the belief that France can become self-contained as to lead production if they are assured of first call on home ores, as well as from Algeria and Tunis, not to speak of Tonkin and Morocco. To secure this it would be necessary to obtain modification of the customs tariff, in the form of an export duty on ores shipped to other than home ports, and customs duties on ores and metals integrally maintained. Establishment of the "Société Mineraux et Metaux" (see p. 412) may make such action an actuality.

Great Britain.—The output of lead ore is steadily falling in the North of England,[2] due to scarcity of labor, lack of development and the high cost of all requisite materials. Available statistics are as follows:

TONNAGE OF GALENA IN THE UNITED KINGDOM

	Tons Raised.	Mean Price of Galena Received by Mines.			Average Price of Pig Lead, Foreign.			Ratio Per Cent. between Galena at Mines and Price of Lead.
		£.	s.	d.	£.	s.	d.	
1912	25,409	11	12	10	17	15	10	65.4
1913	24,282	12	1	0	18	6	2	65.7
1914	26,013	11	18	2	18	13	9	63.7
1915	20,744	14	4	5	22	17	8	62.1
1916	17,107	19	16	6	30	19	6	64.0
1917	15,322	19	13	3	30	0	0	62.2

[1] *Metal Bull.*, Apr. 11, 1918.
[2] *Min. Mag.*, Jan., 1919.

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Galena probably averages about 80 per cent. lead, which was purchased by smelters under satisfactory terms.

The total production of 15,322 tons of galena in 1917 was principally from four mines, namely, Weardale Lead Co., Durham; Mill Close mine, Derbyshire; Wanlockhead mine, Lanarkshire; and Leadhills mine, Dumfries. The Welsh output was only 2002 tons against 12,500 tons in 1900. Prices were fixed by governmental action in Nov., 1916, so that the mines were unable to profit largely from this source. Finally, largely increased wages caused the Government to refund wage increases to companies showing no profit, which refund was later changed to a bonus. The position, therefore, was that if you were losing money you got the bonus; if you were making money you got nothing.

On Jan. 2, 1918, the official price of lead was lowered from £30 10s. to £29, which continued until Nov. 26, when it was raised to £40, probably to offset the loss which the Government had incurred in distributing imported lead at the official price. The close of the year found the Ministry of Munitions in possession of about 70,394 tons of pig lead, plus a large but unknown amount in Canada (perhaps 8000 tons) and about 63,000 tons on the docks in Australia. Nearly all of the 1918 production of Mexico was taken by the British Government under private contracts with the two principal producers, made at a very low price.

Imports are shown in the following tabulation.

From	1917.	1918.
Spain	36,268	49,977
United States	10,084	61,576
Australia	93,654	85,280
Elsewhere	7,118	12,099
	147,124	208,932

Domestic exports amounted to 9364 tons, in comparison with 9316 tons in 1917. Foreign exports were nil, as compared with 133 tons in 1917.

Rhodesia.—The Rhodesia Broken Hill Development Co. has ordered an additional lead smelter, which should be at work by the end of the year, increasing the company's monthly output of lead to 1500 tons.

Spain.—Spanish lead exports amounted to 143,529 tons in 1918 as compared with 154,879 tons in 1917, according to the *Metal Bulletin.* The *Engineering and Mining Journal* reports a total production of approximately 374,000,000 lb., metal in ore.

The Société Minière et Métallurgique de Pennaroya has engaged American engineers for the design of a new lead smelter and refinery to be erected at Pennaroya, Spain.

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Recent Improvements in Lead Smelting

By H. O. Hofman

Introductory; Physical Properties; Alloys; Compounds

Lead Coating by the Schoop Process.[1]—The Schoop pistol, worked with an air-pressure of 3.5 atmospheres, gives an atomizing pressure of 1.5 atmospheres. Increasing this pressure 2.5 atmospheres and higher without raising the working pressure makes the coating fine-grained and dense. Thus, a lead pipe with a wall 1 mm. thick was gas-tight when filled with hydrogen at 5 atmospheres; sheet iron coated with one or two layers of lead did not rust in water. Lead pipe and coated sheet iron prepared with an atomizing pressure of 1.5 atmospheres did not stand either test.

Corrosion of Lead Roofing.—Two cases of corrosion of lead roofing are discussed by J. S. S. Brame.[2] In one, cast sheets laid on wood had been in use for perhaps 200 years; they were corroded where in contact with oak beams, a crust of white basic carbonate having been formed; they were not attacked where in contact with pine boards. In another case the lead had been laid on coke-breeze concrete; it corroded rapidly, the corroded product being reddish and containing higher oxides than lead oxide. It is believed that the corrosion is due to the presence of calcium hydroxide in the cement, which causes the initial formation of calcium plumbite. Another case of corrosion of lead roofing in contact with oak boards, referred to by F. Southerden,[3] showed in a short time the formation of basic carbonates and perforations where in contact with oak, while sheets of the same roof laid on deal remained sound.

Alloys.—In 1917 C. Estes[4] prepared a bibliography of alloys the equilibria of which had been studied; a supplement[5] brings the subject to date.

Conservation of Tin.—A symposium on this subject[6] dealing with bronze bearing metals (Clamer), antifriction and bell metals of the Pennsylvania railroad (Waring), the tin-plate industry (Buck), aluminium bronze (Corse), bronzes, bearing metals, and solders (Burgess, Woodward), babbitts and solders (Thompson), cadmium (Siebenthal), and solder (Lissberger) contains much valuable information on the part lead plays in these alloys.

Two papers by C. W. Hill[7] deal with solders in which tin is replaced

[1] Matsinger, *Elektrotechnik u. Maschinenbau*, p. 69 (1918), through *Chem. Abstr.*, **12**, 2305.
[2] *Jour. Soc. Chem. Ind.*, **37**, 39 (1918); *Jour. Inst. Met.*, **19**, 265 (1918); *Chem. Abstr.*, **12**, 1285.
[3] *Loc. cit.*
[4] Mineral Industry, **26**, 388 (1917).
[5] *Chem. Met. Eng.*, **18**, 312 (1918).
[6] *Bull. Am. Inst. Min. Eng.*, December, 1918, p. 1730; *Trans.*, **60**, 162.
[7] *Chem. Met. Eng.*, **19**, 170 (1918); *Metal Ind.*, **16**, 412 (1918).

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by cadmium, with tin-lead-bismuth solders, the fluxes employed, and tin-lead solders in general.

Lead-magnesium.—The alloy series of these two metals contains the chemical compound Mg_2Pb, freezing at 551.3° C., and two eutectics, one of Mg and Mg_2Pb with about 68 per cent. Pb, freezing at 459° C., and one of Mg_2Pb and Pb with about 97 per cent. Pb, freezing at 251° C.

Ashcroft[1] finds that the alloy of 15 per cent. Mg and 85 per cent. Pb is completely oxidized in the cold in a few hours to a black powder composed of $Mg(OH)_2$ and Pb_2O or $Pb_2(OH)_2$ if exposed to atmospheric oxygen and moisture; he recommends the use of this alloy for removing oxygen from a gaseous mixture, for the preparation of hydrogen by boiling in water, and for other purposes.

Hard Lead Alloys.—A series of hard alloys has been patented by F. C. Frary[2] representing alloys of lead with 2 per cent. calcium, with small amounts of a plurality of alkali earth metals, with a small amount of copper and strontium, with less than 10 per cent. barium and a small amount of copper, and with less than 10 per cent. each of magnesium and copper.

Ulco Hard Metal.[3]—This is an alloy of 98 to 99 per cent. lead with barium and calcium which has properties similar to those of lead hardened with antimony and tin; it can be readily rolled, drawn and extruded; its melting point is about the same as that of lead. The hardening effects of alkali earths upon lead have been noted previously.[4]

Lead-tin-antimony.—O. W. Ellis[5] investigated the tensile and compressive strengths and the Brinell hardness of 21 alloys of lead, tin, and antimony which are to be used in the manufacture of small fittings. The conclusions drawn are: The presence of Sn-Sb compounds tends to render the alloys brittle and weak; the general mechanical properties of Pb-Sn-Sb alloys containing less than 15 per cent. Sn are improved by the addition of Sb in quantities not exceeding 10 per cent.; alloys ranging from 0 to 35 per cent. Sb and 0 to 35 per cent. Sn become harder with an increase of Sb; there exists a region of maximum hardness in the vicinity of the 70–10–20 alloy.

Babbitt and Babbitted Bearings.—Brinell hardness tests at increasing temperatures have been made by J. L. Jones[6] upon babbitts with a lead and a tin base. The results bring out the fact that babbitt with a lead base shows a superior resistance to deformation at the working temperature of bearings. Data as to compression and hardness are given in Table I.

[1] *Trans. Faraday Soc.*, July 18, 1918; *Chem. Met. Eng.*, **19**, 776 (1918).
[2] Canadian Patents Nos. 172033–172037, Sept. 26, 1916.
[3] F. C. Frary and S. N. Temple, *Eng. Min. Jour.*, **106**, 133 (1918); *Chem. Met. Eng.*, **19**, 523 (1918)
[4] Mineral Industry, **25**, 461 (1916).
[5] *Jour. Inst. Met.*, **19**, 151 (1918); *Chem. Abstr.*, **12**, 1285.
[6] *Bull. Am. Inst. Min. Eng.*, August, 1918, p. 1395; *Trans.*, **60**, 458.

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TABLE I.—COMPRESSION AND HARDNESS OF BABBITTS

Load, Lb. per Sq. In.	Tin Base: Sb, 8½; Cu, 8½; Pb, 0; Sn, 83½.		Lead Base: Sb, 14; Cu, 0; Pb, 78; Sn, 8.	
	Compression, In.	Brinell.	Compression, In.	Brinell.
8,500	0.0020	33.6	0.0015	23.8
10,000	0.0020	33.6	0.0020	23.8
11,000	0.0055	33.6	0.0030	24.8
12,000	0.0085	33.6	0.0032	24.8
13,000	0.0140	33.6	0.0102	24.8

Lead-Bismuth-Silver and Lead-Gold-Silver Alloys.—These two series of alloys have been studied thermally and microscopically by M. Goto.[1] The results show that in the first series there is formed a ternary eutectic with Ag, 0.2, Pb, 43.6 and Bi, 56.2 per cent., freezing at 120° C., and in the second a binary eutectic, with Au, 15 and Pb, 85 per cent., freezing at 208° C., and solid solutions of Ag and Au. The author makes a number of deductions[2] from his curves which, judging from the actual results obtained in the Pattinson process, are not realized in practice.

Lead Acetate.—The solubility of lead acetate in water has been determined by Y. Osaka and R. Hara.[3] They found that at 25° C. 100 grams of water dissolve 54.38 grams of lead acetate; at 35°, 87.77 grams; and at 45°, 154.25 grams.

Lead Arsenate.—A process has been patented by I. P. Sihme[4] for the preparation of lead arsenate from litharge and arsenic acid. It consists of adding a small amount of hydrofluoric acid, which greatly hastens the union; the reaction $PbO + H_2SiF_6 = PbSiF_6 + H_2O$ dissolves PbO and furnishes an abundance of lead ions to react with the arsenic acid: $PbSiF_6 + H_3AsO_4 = PbHAsO_4 + H_2SiF_6$.

Lead Ores

Mullanite.—This new member of the jamesonite group of minerals is described by E. V. Shannon.[5] An average of two chemical analyses shows Sb, 25.71 per cent.; Pb, 55.046; S, 18.817; As, 0.249; Cu, none; Fe, trace. The corresponding chemical formula is $5\ PbS.2Sb_2S_3$.

Antimonial Silver-lead Veins.—The veins in the Arabia district of Nevada are discussed by A. Knopf.[6] The analysis of an ore sample by W. G. Mixter shows Sb_2O_5, 51.94 per cent.; PbO, 40.89; Ag, 0.33; Fe_2O_3, 0.60; H_2O, 4.58; insol., 1.66 per cent.

Lead Content of Central Ores and Concentrates.—The mine output of lead and zinc ores by the Central States in 1917 is published by the

[1] *Jour. College Eng.*, Imp. Univ. of Tokio, **9**, 63 (1918).
[2] *Chem. Abstr.*, **12**, 2531.
[3] *Mem. College Science*, Kyoto Imperial Univ., **2**, 147 (1917); through *Chem. Abstr.*, **12**, 444.
[4] U. S. Patent, No. 1267428, May 28, 1918.
[5] *Am. Jour. Science*, **45**, 66 (1918).
[6] *Bull.* 660-H (1918), U. S. Geol. Survey, pp. 249–255.

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United States Geological Survey.[1] From it are taken the lead assays of crude lead ores and concentrates given in Table II.

TABLE II.—LEAD ASSAYS OF CRUDE LEAD ORES AND CONCENTRATES OF THE CENTRAL STATES, 1917

State.	Per Cent. Pb.	
	Crude Ore.	Galena Concentrate.
Arkansas	0.19	80.5
Northern Illinois	0.18	75.4
Southern Illinois	....	70.7
Iowa	....	....
Kansas	0.33	77.0
Kentucky	....	....
Southwest Missouri:		
Soft ground	2.24	76.1
Sheet ground	1.31	75.9
Oklahoma:		
Miami district	0.76	80.4
Anapaw district	0.41	78.8
Wisconsin	0.13	74.7

Purchasing Lead Ores.—The report by O. R. Whitaker on the purchase of lead-silver in Colorado, already referred to,[2] has been made the subject of an extended abstract[3] which is of value to those who can not consult the original or the reprint.

Smelting Practice

Faber du Faur.—The zinc-silver crust obtained in the Parkes process is universally distilled in the Faber du Faur tilting retort furnace. The inventor of this furnace died at Newark, N. J., August 18, 1918, in his 92d year.[4] He was born in Würtemberg, Germany, came to this country in 1850, served in the Civil War, was commissioned a captain, and later engaged in engineering work. His furnace was the first which permitted pouring the molten contents of a closed vessel without removing the latter from the fire. Modern foundries dealing with non-ferrous alloys have followed his example in the construction of their crucible furnaces.

New Publications.—"Metallurgy of Lead," by H. O. Hofman, McGraw-Hill Book, Co., N. Y., 1918, 664 pages, 704 illustrations. This work retains the general characteristics of the author's "Metallurgy of Lead and Desilverization of Base Bullion," but has been almost entirely rewritten and is therefore a new book.

"Innovations in the Metallurgy of Lead," by D. A. Lyon and O. C. Ralston, Bureau of Mines, *Bulletin* 157, 1918, 176 pages. This publication contains the full details of the research work carried on in the experimental station of the Bureau of Mines at Salt Lake City upon the recovery of lead by a chloridizing volatilizing roast and a chloridizing roast fol-

[1] *Press Bull.*, No. 371, June, 1918.
[2] Mineral Industry, 26, 390 (1917).
[3] *Eng. Min. Jour.*, 105, 538, 626 (1918).
[4] *Eng. Min. Jour.*, 106, 368 (1918).

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lowed by lixiviation. The preliminary statements of the main results published by A. E. Wells and by O. C. Ralston, C. E. Williams, M. I. Udy and G. J. Holt, have already been noted;[1] the present bulletin should be consulted for full information.

Smelting in the Ore-hearth.—The Newnam-hearth,[2] which is doing excellent work at smelteries in this and other countries is briefly discussed by J. E. Hardman[3] in connection with the plant erected at Kingdon Lead Mine, Ontario. The paper gives photographs of the plant in the process of erection and after completion. The ore-hearth and its work are treated by W. E. Newnam.[4] The drawings accompanying the article are on a larger scale than those of the author's first paper on the subject,[5] and render the whole discussion more attractive and valuable.

Smelting Cyanide Silver Precipitate.—K. A. Cunningham and A. Feust[6] give details of smelting the cyanide silver precipitate of the Mexican Milling & Transportation Co., Guanajuato, Mexico, in an oil-fired reverberatory furnace, and compare the results with those obtained from oil-fired crucible furnaces. An analysis of the precipitate gave: Ag, 48.33 per cent.; Au, 0.88; Pb, 0.87; Cu, 8.82; insol., 5.40; Fe, 1.16; Al_2O_3, 0.53; Mn, trace; CaO, 3.52; Zn, 15.50; S, 11.54; loss and n.d., 3.45 per cent. The hearth, 11 ft. long, 4 ft. 9 in. wide, and 11⅜ in. deep, sloped from the ends to the tap-hole, which was 4 ft. from the flue end; the roof 8¼ in. high at the flue rose uniformly to 10 in. in a distance of 5½ ft., then more quickly to 16¾ in. for 3½ ft., and was horizontal for the remaining 2 feet. Here the oil burners were placed. The foundation was built of rubble masonry, the working bottom was of fire-brick placed on end, well fitted and closely laid in a thin gruel of fire-clay. The furnace was warmed for 10 days by a fire built on the hearth; then the burners were turned on for several hours each day for four days; and lastly the furnace was brought to a red and then to a white heat. The hearth was seasoned by melting 300 kg. of old slag, most of which was absorbed, and allowing to cool. The bottom was found to be well glazed. Before charging precipitate, the hearth was painted with a thin gruel of fire-clay, and this operation was repeated before every subsequent melt. The furnace was operated once a week for 2½ months, a melt taking from 16 to 28 hours. The precipitate was fluxed with 8.76 per cent. borax glass, 12.64 per cent. soda ash, 12.73 per cent. broken glass, and 2.12 per cent. lime (50 per cent. CaO). During 9 melts there were consumed 3.569 liters of gas-oil per kg. of bullion produced. The 5331 kg. of

[1] MINERAL INDUSTRY, 26, 396, 400 (1917).
[2] MINERAL INDUSTRY, 24, 459 (1915).
[3] *Trans. Can. Min. Inst.*, 20, 180 (1917).
[4] *Eng. Min. Jour.*, 106, 101 (1918).
[5] *Trans. Am. Inst. Min. Eng.*, 57, 579 (1917); MINERAL INDUSTRY, 26, 394 (1917).
[6] *Min. Sci. Press*, 117, 621 (1918).

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precipitate smelted gave 2529.254 kg. of bullion. A clean-up of the furnace showed that it had absorbed 3.57 per cent. of the gold and 3.61 per cent. of the silver; the two dust-chambers gave 5 kg. of dust assaying 4 oz. Au and 300 oz. Ag per ton, and 3 kg. of dust assaying 0.2 oz. Au and 230 oz. Ag per ton. The slag from the reverberatory gave upon analysis Au and Ag, 0.003 per cent.; Pb, 0.35; Cu, 0.10; SiO_2, 31.34; FeO, 4.25; Al, 0.60; CaO, 8.10; Zn, 16.50; S, 23.05; Na, 3.00; B, 2.81; O and loss, 9.90 per cent. The bullion was 883 fine. The conclusion drawn is that the reverberatory furnace is preferable to the crucible furnace; it has the disadvantage that in running only once a week, with a small plant the returns for the values in the precipitate are not as quick as with the crucible furnace.

Roasting Telluride Ores.—This subject is discussed by A. L. Blomfield and J. M. Trott[1] as a preliminary treatment to cyanidation. To the lead smelter who often has to add such ores to his blast-roasting charges, the losses in roasting are of interest. At the Golden Cycle mill, Colorado Springs, the ore is treated in an Edwards duplex reverberatory roasting furnace, 115 ft. long and 13 ft. wide, with 27 pairs of rabbles, making 3 r.p.m.; and a cooler, 44 ft. long and 14 ft. wide, with 11 pairs of rabbles, making 6 r.p.m.; the temperature reaches a maximum of 850 to 900° C.; it is 485° C. at the discharge point of the furnace, and 278° at that of the cooler; the draft shows a depression of 0.2 in. water; the volume of gas is 208,000 cu. ft. per minute.

Dwight-Lloyd Machine.—The pallets of the 42-in. standard machine have herringbone grates which are likely to become clogged by clinkers. Most smelteries require grate cleaners, often one man for two machines; a few manage the charges and machines in such a way that they have been able to dispense entirely with grate cleaners. Mechanical grate cleaners[2] have been devised, but have not been satisfactory. The Stewart finger grate is finding favor. The Riddell-Davison grate,[3] developed at Port Pirie, N. S. W., and manufactured by the Missouri Malleable Iron Co., St. Louis, Mo., frees the grate openings from clinkers by having a stationary bar in a continuous elevated slot entering below the top surface of the grate and raising the cake from the pallets.

Another improvement is the successful use of fuel dust as igniter, developed by Wright, Erickson, and Hamilton[4] at the Midvale smeltery, Utah. An injector burner has replaced the Austin igniter. From 450 to 500 lb. of dust per day have been found to be sufficient for one machine which required 70 gal. of fuel-oil. The ignition is also more satisfactory,

[1] *Bull. Am. Inst. Min. Eng.*, August, 1918, p. 1265; *Trans.*, **60**, 118; *Eng. Min. Jour.*, **106**, 400 (1918)
[2] Hofman, "Metallurgy of Lead," 1918, p. 199.
[3] Riddell, *Eng. Min. Jour.*, **106**, 832 (1918).
[4] *Chem. Met. Eng.*, **19**, 797 (1918).

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in that the oil flame often restricts the inflow of air necessary for roasting and thus fuses the top of the charge; the latter then offers increased resistance to the penetration of the air.

S. E. Fraser has patented[1] an ignition hood which is considered to be an improvement over the one in common use with the Austin igniter.[2] The hood, made of fire-brick bound with bars and rods, has the form of a shallow elliptical dish which has been inverted. The burner introduces the flame tangentially so that it swirls around, fills the cavity, and heats by contact and radiation; additional air may be admitted through the roof.

Blast-furnace Thimble-top.—The gases of lead blast furnaces are withdrawn either from the top or the side. The furnaces of the United States in the former case have a high top, extending above the feed-floor, and a down-take; in the latter, the top is level with the feed-floor, and the gases are withdrawn beneath it. In Europe many furnaces have a Darby tube, *i.e.*, a vertical pipe in the center of the furnace, extending a distance into the enclosing charge, which carries off the gases. With oblong furnaces the pipe has been changed into a rectangular duct; the throat of the furnace has been enlarged to make room for the duct and has been named "thimble-top."

Australian metallurgists have followed the European example, and American smelteries are adopting it, *e.g.*, at Selby, El Paso (see below), and other places. E. P. Mathewson[3] finds that the new arrangement has the following advantages: There is a better distribution of charge, resulting in a decreased formation of wall accretions and a consequent lengthening of campaigns; a decrease in loss of lead by dusting and volatilization, due in part to a reduction of volume of gas to be handled; an improvement in the working conditions on the feed-floor; and a diminution in the coke consumption.

Continuous and Intermittent Tapping.—The continuous flow of matte and slag over a trapped spout has become general with the present large-size copper blast furnaces treating sulphide ores. In lead smelting intermittent tapping is the rule because with a continuous flow zincky mush and arsenical mixtures having high melting points are likely to remain in the furnace and cause trouble. Before tapping, the level of the lead in the crucible can be raised, when necessary, by closing the outflow of the lead well, and cause the undesirable material floating on the lead to be brought to the level of the slag-tap and carried out by a large volume of slag.

Fuel.—The introduction of bituminous coal into blast furnaces

[1] U. S. Patent No. 1262500, April 9, 1918.
[2] Hofman, "Metallurgy of Lead," 1918, p. 197.
[3] *Eng. Min. Jour.*, 106, 140 (1918).

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through tuyères has been practised for some years in Japan in connection with pyritic smelting of sulphide copper and has led to a reduction of the coke required, to a better oxidation of sulphur, and to a lengthening of campaigns by the diminution of wall accretions and thereby of hanging of charges. The work at Ashio is noted in the literature.[1] While the Japanese crush the coal through a ½-in. screen and introduce it by hand with a cylinder and piston, in this country experiments are under way with fuel dust and mechanical feeding.[2] In one Japanese lead plant, crushed coal is introduced through the tuyères, as in the copper furnaces, and works satisfactorily. In this country fuel dust has been tried in a small way. In one furnace the back tuyère, which is usually closed, was opened, a hole drilled and coal dust blown in; the result was that the back crust, which reached a long distance into the furnace, was fused in from two to three hours and the hearth cleared. Trials with fuel dust in several tuyères have been satisfactory; it looks as if in the near future a considerable part of the carbon necessary for smelting may be introduced into the furnace through the tuyères as dust from bituminous coal, instead of being charged at the throat in the form of coke.

In making up a blast-furnace charge, the composition and fusibility of the coke-ash has to receive due consideration. Analyses of coke-ash are difficult to obtain. The investigation of A. C. Fieldner, A. E. Hall and A. L. Feild into the "Fusibility of Coal Ash and the Determination of the Softening Temperature"[3] contains analyses of the ash of 110 coals of the country; it thus furnishes valuable information as to composition, and studies the refractoriness in atmospheres of H, CO, CO_2 and their mixtures. The publication is of much interest to the lead smelter.

F. C. Miller[4] in a discussion of the development of the coke industry in Colorado, Utah and New Mexico, gives the facts recorded in Table III, showing the physical properties of Western coke.

Lead Smelting at El Paso, Texas.—These works, established in the early 80's by the Consolidated Kansas City Smelting & Refining Co., have undergone many changes. The descriptions by Vail[5] and Easter[6] show how the modes of operation had to be altered to meet the new requirements due to the changes in the character of ore and to the general progress of the art. C. De Kalb[7] describes the work done at present. The leading change since 1915 is the new shape of the throat of the blast furnace, which has received a thimble-top, and with this the improved method of introducing the charges. Drawings of the blast

[1] *Min. Sci. Press*, 114, 278 (1917).
[2] T. W. Cavers, U. S. Patent No. 1259467, March 12, 1918.
[3] *Bull.* 129, Bur. Mines, 1918.
[4] *Bull. Am. Inst. Min. Eng.*, August, 1918, p. 1307; *Trans.*, 61.
[5] Mineral Industry, 23, 473 (1914).
[6] Mineral Industry, 24, 462 (1915).
[7] *Min. Sci. Press*, 116, 679 (1918).

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TABLE III.—THE PHYSICAL PROPERTIES OF WESTERN COKE

Coke.	Apparent Specific Gravity.	Per Cent. Coke.	Per Cent. Cells.	Weight per Cu. In., Grams.	Crushing Strength, Lb. per Sq. In.
Colorado Fuel & Iron Co., Colo.:					
Tabasco	0.842	47.31	52.60	13.80	1,620
Starkville	0.814	44.76	55.24	13.34	1,500
Sopris	0.988	54.06	45.94	16.11	2,500
Segundo	1.120	59.69	40.31	18.46	2,500
Tercio	0.818	45.54	54.46	13.40	1,560
Cardiff	0.785	43.23	56.78	12.84	1,553
Crested Butte	0.805	44.20	55.80	13.17	1,476
Victor American, Colo.:					
Delagua	0.722	38.34	61.66	11.63	1,120
Hastings	0.757	40.96	59.04	12.40	1,250
Gray Creek	0.793	42.12	57.88	12.70	1,300
Dawson Fuel, N. Mex.:					
Dawson	0.738	40.72	59.28	12.05	900
St. Louis, Rocky Mountain & Pacific, N. Mex.:					
Gardiner	0.752	40.41	59.59	12.29	1,163
Koehler					
American Smelting & Refining Co., Colo.:					
Cokedale	1.050	55.92	44.08	17.20	2,485
Durango	0.784	42.18	57.82	12.84	1,275
Utah Fuel Co., Utah:					
Sunnyside	0.783	44.53	55.46	12.80	1,546

furnace and a detail of the top make the changes clear. The gases are withdrawn beneath the feed-floor as before; the throat of the furnace has been enlarged so as to make room for an oblong iron box, at one end of which is the opening for the withdrawal of the gases. The box consists of two truncated cones joined at the bases; the upper is 1 ft. 6 in. high and 4 ft. wide, the lower 4 ft. high and 3 ft. 5 in. wide. The box, 7 ft. 8 in. deep, reaches to the ends of the furnace, extends 2 ft. 8 in. beneath the lower edge of the downcomer, and leaves between the box and furnace walls a charging space 2 ft. wide. The advantages of the thimble-top are noted above.

Smelting and Refining at Kellogg, Idaho.—The leading features of this latest silver-lead plant have already been given with the cross references.[1] Details of the work done at present and several changes and additions which have been made are discussed by Rice.[2] The leading improvement has been the substitution of pulverized coal for oil. Reverberatory furnaces, kettles, and retort furnaces are fired with fuel dust made of slack coal. The return-circuit Holbeck system of the Bonnot Co., Canton, Ohio, is the one employed. The coal is crushed in a closed circuit under a partial vacuum, and the fuel dust, suspended in air, is circulated throughout the plant. There is always a surplus of dust over air, which exceeds the proportion at which the mixture might explode. The amounts of dust necessary for the various burners are withdrawn from the main at the desired points by means of deflectors, while the remaining excess is returned to the bins of the system. At a

[1] MINERAL INDUSTRY, **26**, 391 (1917).
[2] *Eng. Min. Jour.*, **106**, 91, 436, 649, 743, 771, 824, 944, 993 (1918).

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burner sufficient air is introduced to obtain complete combustion. A Bonnot pulverizer crushes 20 tons of coal in an 8-hr. shift, an amount sufficient for the daily needs of the present plant.[1] A screen analysis of the dust shows that 5 per cent. will remain on a 100-mesh and 85 per cent. pass a 200-mesh screen. The dried coal is held in a closed bin of 1-ton capacity from which it is fed by a plunger feeder to the pulverizer; from this the dust is drawn upward through a separator and delivered to a 25-ton dust-bin which feeds its circuit with the required amount, which is controlled automatically by the rate of consumption.

The lead for the blast furnaces is obtained from the company's galena concentrates; the iron from middlings of the ore-dressing plant of the company and from pyrite-magnetite gold concentrates from Alaska. All ores are sulphides, and have to be roasted and blast-roasted.

The storage and sampling divisions have proved to be ample for the increased tonnage of the plant.

In the roasting department a circular rotating cast-iron table with stationary rabble-arm has been attached to a Wedge kiln (21 ft. 6 in. in diameter) to remove the roasted pyritic ore that it may be air-cooled and sprayed with water before it is delivered to the traveling belt carrying the components of the blast-roasting charges. The increase of blende in the galena concentrate necessitated the addition of three standard Dwight-Lloyd sintering machines, so there are now seven in operation. The herringbone grates in the pallets of the original machines have been replaced by self-cleaning Stewart grates, first installed at Trail, B. C.[2] The grates consist of toothed bars, alternately rocking and fixed; when a pallet moves over the discharge-end, the clinkers that may have formed are broken by the teeth and discharged when the pallet drops.

A new blast furnace, 48 by 180 in. at the tuyères and 14 ft. high, has been added, making a total of four, which are placed at 36-ft. centers. A furnace has two fore-hearths placed in series; the first is 6 ft. in diameter and 3.5 ft. deep, the second 5 ft. in diameter and 2.5 ft. deep. Two Ingersoll-Rand turbo-blowers furnish 24,000 cu. ft. of free air per min. at a pressure of 48 ounces. The matte from the fore-hearths is tapped into small ladles suspended from the overhead crane; the slag is run from the second fore-hearth into motor-dumping Treadwell pots of 130 cu. ft. capacity; slag-shells are dumped onto a skull grizzly, broken, and returned to the blast furnaces; the lead bullion is transferred by overhead ladles to two 50-ton drossing kettles from which it is delivered by means of a

[1] According to C. F. Herington in "Powdered Coal as Fuel," Van Nostrand, N. Y., 1918, p. 3, the cost of a fuel-dust plant with the ordinary conveyor system is 1.5 times as great as with the pneumatic, and the cost of operating 1.3 times as great.

[2] Hofman, "Metallurgy of Lead," 1918, p. 199.

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Miller pump in half an hour to the softening furnaces of the refinery. The blast-furnace charge carries from 35 to 40 per cent. Pb and from 1 to 3 per cent. Zn; the slag averages SiO_2, 32–33; FeO, 32; MnO, 3; CaO, 16; ZnO, 2–4; Pb, 1 per cent. (wet). The matte-fall is 12 per cent., a figure that will be reduced by double treatment in Dwight-Lloyd machines. A furnace treats in 24 hr. from 200 to 250 tons of charge and produces from 120 to 150 tons of drossed lead bullion.

The refinery has been enlarged by two 80-ton softening furnaces, two 50-ton desilverizing kettles, one silver-refining furnace, and a reverberatory furnace for the treatment of antimony skimmings. The market lead is molded from four 50-ton merchant kettles with Miller casting machines. Four men cast with such a machine and load into cars per hour 20 tons of lead in 100-lb. pigs. The lead averages Pb, 99.989; Sb, 0.002; Cu, 0.0005 per cent.; Zn, trace; As, none; Bi, none; Ag, 0.15 oz. per ton. The cement silver from the sulphuric acid parting plant is melted in a double Monarch furnace and poured from it.

Ideal Silver-lead Smeltery.—The lay-out of such a plant which is to treat daily from 1000 to 3000 tons of charge is given by G. C. Riddell.[1] The plant is to be erected on a level site which has a declivity to serve as slag dump; the tracks are to be of standard gage; a loop-system is to be provided for charging the blast furnaces; the storage facilities are to be ample; automatic conveying and weighing are to facilitate handling; vital units in handling are duplicated to prevent stoppages; an ample supply of electric power and of water are to be furnished.

The sampling mill is to treat 50 tons per hour; it is provided with one No. 5 gyratory crusher, two 16 by 36-in., one 14 by 30-in., and one 12 by 12-in. rolls and Vezin samplers. The roasting division is to be provided with a Wedge kiln to treat pyritic concentrates and a double Dwight-Lloyd plant for lead ores, containing three 42-in. machines for rough roasting and four for re-treating and sintering the rough-roasted product after it has been crushed. Troublesome flotation slimes are to be compacted by being moistened and then passed through an inclined revolving cylinder from 2 to 3 ft. in diameter and 8 ft. long; the moistened slime is discharged in the form of balls of various sizes which, added to blast-roasting charges, cause no trouble on the Dwight-Lloyd machines. This method of handling slimes was developed in Australia in 1917.

The smelting section is to have three blast furnaces which are 52 by 180 in. at the tuyères and have a working height of 25 ft.; each furnace is to be furnished with the necessary air by a turbo-blower delivering from 6500 to 8000 cu. ft. of air at a pressure of from 60 to 70 ounces. The proposed great height of 25 ft. is taken from Australian practice where,

[1] *Eng. Min. Jour.*, **106**, 115 (1918).

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at the Cockle Creek plant, Boolaroo, N. S. W., satisfactory work with zincky ores was obtained only when the furnaces were pushed, *i.e.*, the blast pressure increased to 70 oz., the height of the furnace also being necessarily increased to prevent overfire and to obtain a cool top. A furnace of this character will smelt in 24 hr. 550 tons of charge with 11.0 to 11.5 per cent. of coke and make slags with 12 to 13 per cent. ZnO and only 0.75 to 1.00 per cent. Pb. The furnaces have thimble-tops. The gases from the roasting and smelting furnaces pass through the usual chambers and flues, and are freed from remaining dust and fume by five sets of Cottrell precipitators, each with 64 pipes, 12 in. in diameter. The slag is handled in 5-ton steel pots having tap-holes 12 in. above the bottom; the matte-fall is from 1 to 2.5 per cent., so that a single oil-fired settler on wheels suffices; the liquid lead bullion is transferred in ladles to the refinery by a monorail electric hoist, which also handles matte pots and other heavy materials.

The refinery, desilverizing by the Parkes process, is to have six 60-ton drossing kettles, three 120-ton (?) softening furnaces, six desilverizing kettles, six merchant kettles, a Miller casting machine for molding market lead, nine retorts for zinc crusts, three cupelling and silver-refining furnaces, an electrolytic plant for parting doré silver and a crucible furnace for melting gold ore. The paper records many details of the smelting division, but confines itself to the general features of the refinery section, and gives space to the consideration of safety and welfare appliances.

Smoke.—Six photographs with descriptive tests[1] show the devices used at the plant of the United States Smelting & Refining Co., Midvale, Utah, for withdrawing fumes from furnaces, for filtering gases, and for collecting filtered fume.

Cottrell Process.—A. A. Heimrod and H. D. Egbert discuss[2] the application of this process to the removal of dust from hot roaster gases, previous to the conversion of SO_2 into SO_3 or H_2SO_4, and to the condensation of acid fume from acid concentrators and from the absorption towers in plants using the contact process.

Hygiene.—Modern lead works pay considerable attention to the removal of lead-bearing dust and fume, and in general to the health and safety of the men employed. Many plants issue pamphlets to awaken the interest of the men. Such a publication is the one by Dr. H. C. Ernst of the United States Metals Refining Co., East Chicago, Ind.[3] Again, safety appliances[4] are found today which were sadly missing in the earlier

[1] *Eng. Min. Jour.*, **106**, 446, 447 (1918).
[2] *Chem. Met. Eng.*, **19**, 309 (1918).
[3] *Eng. Min. Jour.*, **105**, 384 (1918).
[4] G. M. Douglass, *Eng. Min. Jour.*, **106**, 105 (1918).

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days. Thus, *e.g.*, dust and fume are removed by suction fans from places where formed and carried to bag-houses. This procedure has often furnished a return in values which is greater than the cost of removal. Protection against mechanical injury is provided; cleanliness and order are enforced, records of accidents and cases of plumbism in the various divisions are kept separate, and thus a rivalry created which has greatly reduced the number of cases of injury and sickness.

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MAGNESITE

By S. H. Dolbear

For many years California was the only State producing magnesite. The development of large deposits of crystalline magnesite in Washington was commenced in 1916, and in 1917 these new mines produced 105,000 tons of crude ore. The production of the two States for 1918 was 231,605 short tons of crude ore, a decrease of 27 per cent., when compared with 316,838 tons in 1917. Of this total in 1918 84,077 tons came from California and 147,528 tons from Washington. Thus Washington has become the premier state in magnesite production, taking the place of California, which has hitherto ranked first.

The sedimentary deposits of Nevada, near Las Vegas, while classed as magnesite, carry enough lime to make them almost dolomitic in character, and this, with other impurities, principally silica, make the whole so low grade, that, in spite of their size, they are not regarded as important, at present.

The decrease in domestic production was due in part to importations from Canada, and in part to the high prices demanded for calcined ore. This brought about the substitution of dolomite for magnesite. Embargoes and shortage of cars also had their influence. Calcined dolomite is less satisfactory than magnesite, but it occurs in large quantities close to many points of consumption, and is, therefore, much cheaper. Many magnesite mines were operated only intermittently during the year, and by the first of November all of the small mines were closed and the few larger ones which continued operations were working with reduced forces.

With the conclusion of the war plans have been made to resume importations from the large deposits in Austria. The Italian Government has issued permission for the shipment of magnesite from Trieste, if destined for the United States. All import restrictions have been removed. The stocks in Trieste are not definitely known, but are believed to be large, and there are possibly stocks at other European ports as well. It seems doubtful if American magnesite can compete with that of foreign countries. Foreign labor is cheap and the product comes over at low rates. American producers, through the American Mining Congress, are seeking a tariff sufficient to protect the American industry.

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California.—The California mines worked only intermittently in 1918, the slack being due to a combination of circumstances. The substitution of dead-burned dolomite for magnesite, car shortage and embargoes, the falling-off in demand for the lighter grades for building purposes, and competition from the Chewelah fields, all contributed to reduce operations. The outlook for the future is not particularly bright. If domestic ore is to be used for refractory purposes, it will come largely from Washington because of the low production costs. Prior to 1915 the principal consumers of California magnesite were the paper manufacturers in Washington and Oregon. There has now been developed a method of substituting dolomite for magnesite in this work, and one large manufacturer has erected a dolomite calcining plant near Colville, Washington.

For plastic use California will control the domestic field, having as its chief competitor the Grecian mines. The Washington magnesite ore, for the most part, is too much discolored for plastic manufacture. The demand for white caustic magnesite for plastic manufacture is not large, and though increasing from year to year, will be satisfied by a few thousand tons annually.

Washington.—During the year 1918 the Northwest Magnesite Co. produced 80,432 tons of crude magnesite, which was chiefly manufactured into a dead-burned sintered magnesite used by the steel trade for refractories.

About $700,000 was spent in erecting a reduction plant at Chewelah, Wash., which has a capacity of making about 10,000 tons of dead-burned magnesite per month. This plant consists of six rotary kilns, 125 by 7½ ft., the necessary grinding machinery, etc. At the mine development work was carried on, which proved sufficient ore to supply the requirements of the United States for many years. This ore is of the crystalline form and similar to the deposits in Austria. Whether this property can operate successfully after the war will probably be dependent upon the attitude of the Government regarding a tariff on this material, as the freight rate from Washington State to the eastern seaboard is at present $16.50, as compared with the pre-war Austrian ocean rate of $2.00 per ton.

The American Mineral Production Co. is another large producer, and could produce 10,000 tons of crude ore per month. The company has shipped several thousand tons per month from Valley to Irvin, 8 miles east of Spokane, where it is converted into ferro-magnesite at the plant of the International Portland Cement Co. The Valley Magnesite Co. operated deposits near Valley, Wash., a portion of the year.

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STATISTICS OF CRUDE MAGNESITE IN THE UNITED STATES
(Tons of 2000 lb.)

Year.	Production. (a)	
	Tons.	Value.
1905	3,933	$15,221
1906	7,805	23,415
1907	7,561	22,683
1908	6,587	19,761
1909	9,465	37,860
1910	12,443	74,658
1911	9,375	75,000
1912	10,512	84,096
1913	9,632	77,056
1914	11,293	124,223
1915	30,499	274,491
1916	154,974	1,393,693
1917	316,838	2,899,818
1918	231,605	1,812,601

(a) U. S. Geol. Surv.

IMPORTS OF MAGNESITE INTO THE UNITED STATES

	1916.		1917.		1918.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined (Medicinal)	54,981	$14,659	34,808	$11,819	423	$312
Carbonate (Medicinal)	9,202	1,048	23,197	6,095	*Nil*	.....
Sulphate	674,594	4,036	101,170	1,647	2,046	196
Magnesite:						
Calcined, not purified	150,689,445	634,447	60,554,420	232,105	38,098,815	824,022
Crude	18,539,704	204,183	7,931,159	232,601	10,863,417	103,233

IMPORTS OF MAGNESITE CALCINED, NOT PURIFIED
(Fiscal years ending June 30, in short tons)

Country.	1914.	1915.	1916.	191.7	1918.
Europe:					
Austria-Hungary	134,260	52,086	.....	.....	.....
Belgium	11	.....	.....	.....	.....
Germany	2,578	722	12	.....	.....
Greece	3,232	4,437	11,413	1,792	.....
Denmark	58	103	.....	.....	.....
Italy	.....	710	.....	.....	.....
Netherlands	4,191	3,554	1,950	.....	.....
Norway	.....	.....	22	.....	11
United Kingdom—					
England	12	130	.....	27	1
Scotland	1	151	349	757	931
North America:					
Canada	404	948	2,440	2,148	10,804
Mexico	.....	.....	.....	.....	.....
Other countries	.....	(a)508	.....	.....	(b)2
Total	144,747	63,348	16,186	4,724	.....

(a) Venesuela. (b) South Africa.

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THE PRINCIPAL SUPPLIES OF MAGNESITE
(In metric tons)

Year.	Austria-Hungary. (a)		Greece.		India. (b)	Italy. (b)	United States. (b)	Canada. (b)
	Crude.	Calcined.	Crude.	Calcined.				
1904	.....	53,781	9,133	.....	1,193	.....	2,585	.....
1905	.....	92,359	37,063	.....	2,645	.....	3,568	.....
1906	.....	87,765	40,584	.....	1,861	.....	7,093	.....
1907	452	113,695	55,816	.....	188	.....	6,858	.....
1908	212	87,049	63,079	.....	7,655	.....	5,994	109
1909	341	182,911	18,073	19,182	5,264	.....	11,251	299
1910	1,027	125,666	56,797	16,609	199	.....	8,588	293
1911	77	182,911	86,956	27,530	3,546	.....	8,505	800
1912	.....	171,196	106,338	33,848	15,626	.....	9,534	1,555
1913	.....	200,947	98,517	31,815	16,468	600	8,741	467
1914	.....	.....	136,701	28,563	1,706	1,410	10,248	325
1915	.....	.....	159,981	28,563	7,570	9,200	27,669	13,407
1916	.....	.....	145,533	27,248	17,924	18,252	140,592	50,284
1917	.....	.....	162,938	69,837	18,495	31,071	287,433	52,699
1918	.....	.....	(c)40,000	.....	.....	.....	225,161	35,711

(a) Exports. (b) Crude magnesite. (c) Estimated.

Foreign Countries

Canada.—Production of magnesite in Canada fell to 39,365 short tons in 1918, as compared with 58,090 in 1917. Due to the high prices which prevailed, the value of the output was considerably greater. The official valuation of the 1917 production was $728,275 as compared with $1,016,765 for the smaller tonnage in 1918.

Argenteuil County, Quebec, contributed the whole of the Canadian output last year. It is marketed as crude ore, calcined and dead-burned clinker, the last being sintered in rotary kilns after mixture with 5 per cent. of iron ore in the form of magnetite. There was a greater proportion of calcined and clinker produced than before. The 16,697 tons of crude ore sold averaged $9.50 per ton; calcined, $25; and clinker, $35 to $40. The Canada Cement Co. at Hull and Montreal did the sintering. Exports were valued at $816,553 in 1918.

Greece.—Magnesite has been mined at five points in Greece, the more important of them being Yerakino. Other sources are situated at Cokino Petra on the peninsula of Chalcidice, quarries northeast and southeast of Vavdoes, and at Galatista. The Yerakino mines have been worked since 1905, and are still far from being fully developed. Before the war, the mine owners calcined practically their total output and then shipped it to Holland, where it was re-shipped to different countries. These shipments reached 10,000 metric tons of ore, representing 21,000 tons of the crude ore annually, besides 2000 or 3000 tons of crude ore sent to Italy, France and Holland. After the outbreak of the war, the process of calcination was halted on account of the lack of fuel and the impossibility of obtaining westward-bound freight accommodations.

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In 1916 the shipment of the ore to Holland had fallen to 320 tons of crude and 730 tons of calcined magnesite, and 1917 shows no record of sales to that country. Exports to the United States were 12,914 tons of crude ore in 1916, but in 1917 there were none. The British Government was the principal purchaser in 1915, 1916 and the first half of 1917, as shipments there reached in that period a total of 40,000 tons, at prices varying from $7.50 to $12.50 per ton, f.o.b. Yerakino. Owing to increased cost of labor, machinery and transportation, there has been an increase in price, and on this account since July 1, 1917, practically no new sales in former markets have been made.

Mexico.—The International Magnesite Co., controlling magnesite deposits on Santa Margarita Island, Mexico, in the Gulf of Lower California, was compelled to cease operations because of embargoes. The company owns a calcining plant at Chula Vista, near San Diego, Calif., and the ore is shipped from the deposits to this plant by water.

South Africa.—Magnesite mining in South Africa has been chiefly confined to the Barberton district of the Transvaal. The deposits are small and yield but a few hundred tons per year.

Venezuela.—At Margarita Island two American companies were interested, the American Magnesite Co., and the Magnesite Products Co. Because of political influences, and the embargo on importations in the United States, the mines were idle. The deposits are reported to be very large, of exceptional purity and advantageously situated near tidewater, so as to afford low transportation costs.

Metallic Magnesium[1]

Three plants were producing magnesium at the end of 1918. The American Magnesium Corporation, Niagara Falls, N. Y., was operating a plant at Niagara Falls and one at Rumford, Maine, and the Norton Laboratories (Inc.), Madison Avenue and Forty-first Street, New York City, was operating a plant at Lockport, N.Y. The Dow Chemical Co., Midland, Mich., produced magnesium in the second half of 1918, but ceased production before the end of the year. The Rumford Metal Co., Rumford, Maine, was engaged in producing magnesium during the first half of 1918, but sold the plant to the American Magnesium Corporation, which continued the business to the end of the year. There were therefore four producers and four plants in operation during part of the year, and three plants and two companies operated continuously.

Only one firm sold magnesium in the powdered form; hence exact figures of the quantity marketed as sticks and as powder can not be given separately without revealing confidential information. It may be stated,

[1] U. S. Geol. Surv.

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however, that about three-fifths of the total was sold as sticks and two-fifths as powder.

METALLIC MAGNESIUM PRODUCED IN THE UNITED STATES, 1915–1918

Year.	Number of Producers.	Quantity, Pounds.	Value.	Average Price per Pound.
1915	3	87,500	$440,000	$5.00
1916	4	75,400	311,462	4.13
1917	5	115,813	233,626	2.02
1918	4	284,188	615,217	(a) 2.16

(a) As 1918 was the first year in which powdered magnesium was reported to the Geological Survey, the average price of $2.16 a pound for all magnesium sold in 1918, which includes a large quantity of powdered magnesium, is not comparable with the average price for 1917, which is based on magnesium in sticks only. The average price for stick magnesium in 1918 was about $1.81 a pound, or 21 cents less than in 1919.

The normal demand for the metal prior to 1915 was for manufacturing the alloy called magnalium and for deoxidizing nonferrous metals; the powdered form was used for flash-light photography and for pyrotechnics. During the war the use of magnesium powder in photography probably did not decrease materially if at all, and a demand new in the United States arose for it—the use in star shells, flares, tracer bullets and other projectiles, as a high-explosive ingredient in trench-mortar shells, and as an alloy with aluminium in airplane engine and frame castings.

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MANGANESE

By Allison Butts

A year and a half ago it was generally thought that the manganese situation presented a rather serious aspect. The customary supplies from Brazil and India were, because of the shortage of bottoms, not reaching United States ports, and it was a question as to whether the ever-increasing demands of steel and alloy manufacturers could be supplied from domestic sources. American steel plants had been accustomed to and preferred the use of 80-per cent. ferromanganese, and the domestic supplies of ore suitable for making this alloy were limited. Lack of definite information on this point, and lack of knowledge as to how to use such low-grade ores as were known to exist, were only two of the many factors that combined to make up the great total of America's unpreparedness for entering the war. What saved the situation, brought about production, and gave the domestic industry knowledge of domestic manganese resources, was the smelting of lower-grade ores, with competitive bidding, and the high prices actually paid.

In the spring of 1918 manganese ore was commanding four to five times the price that it sold for in 1913, and grades were being accepted which could not have been marketed at any price five years earlier. With this incentive, American miners proved equal to the situation, and production of ore, such as it was, increased by leaps and bounds until the middle of October, when information came from Washington that production had reached such a stage that, should importation be entirely suspended, the country could probably fulfil all requirements through domestic supplies. There is reason to believe that there was no intention to create such a situation, as it would certainly have been undesirable. It is now known that the United States has manganese resources assuring the country independence of imports should the necessity arise. At the same time the industry appreciates the fact that there are no manganese deposits in the United States comparable with those of Brazil and India in quality and quantity; that probably when war demands have ceased, and ample shipping is again available, manganese mining will return to much the same condition as in pre-war days; and that no amount of protection and Government fostering will ever enable American manganese producers to compete with foreign countries as miners of manganese ore.

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PRODUCTION OF MANGANESE ORES IN THE UNITED STATES
(In long tons)

	Mn 40 per cent. or more (c)					Less than 40 per cent. Mn. (c)				
	1914.	1915.	1916.	1917.	1918.	1914.	1915.	1916.	1917.	1918.
Alabama	.....	200	(a)	(a)	709	.....	.....	.....	.....	443
Arizona	.....	339	2,754	(a)	17,654	.....	1,452	7,698	(a)	12,840
Arkansas	.....	588	6,131	(a)	7,731	1,970	3,355	3,869	(a)	9,173
California	501	2,563	6,054	(a)	24,067	.....	.....	221	(a)	68
Colorado	.....	150	110	.....	3,276	39,881	30,921	107,113	(a)	94,603
Georgia	.....	3,168	(a)	(a)	6,679	.....	676	(a)	(a)	11,696
Michigan	.....	.....	.....	.....	.....	.....	.....	.....	(a)	22,673
Minnesota	.....	.....	.....	.....	.....	55,192	42,973	240,403	(a)	860,696
Montana	.....	.....	3,268	(a)	199,932	.....	.....	(a)	(a)	.....
Nevada	.....	.....	(a)	(a)	19,872	.....	104,498	122,429	(a)	80,354
New Jersey	.....	.....	.....	.....	64	(b)100,198	(b)159,318	(b)198,817	(b)155,332	(b)146,796
New Mexico	.....	.....	.....	(a)	3,126	.....	.....	16,574	(a)	33,307
N. Carolina	.....	.....	.....	(a)	315	.....	.....	.....	.....	30
Oregon	.....	.....	.....	.....	198	.....	.....	.....	.....	.....
S. Carolina	(a)	.....	.....	(a)	100	.....	.....	.....	(a)	850
S. Dakota	.....	.....	.....	.....	31	.....	.....	.....	.....	.....
Tennessee	.....	.....	212	(a)	4,162	.....	150	(a)	(a)	2,358
Texas	.....	(a)	(a)	(a)	380	.....	.....	.....	(a)	.....
Utah	.....	(a)	1,282	(a)	5,100	.....	55	(a)	(a)	.....
Virginia	1,724	1,620	4,388	(a)	10,928	1,222	1,944	37,729	(a)	12,776
Wisconsin	.....	.....	.....	.....	.....	.....	10,616	3,982	(a)	215,839
Other States	410	80	2,798	114,216	42	.....	14,537	8,785	448,171	50
Total	2,635	8,708	26,997	114,216	304,366	198,463	355,958	548,803	1,103,503	1,503,552

(a) Included in "Other States." (b) Zinc ore residuum. (c) In 1918 the dividing line for percentage of Mn was changed from 40 to 35 per cent.

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Reports made to the Geological Survey by operators of manganese deposits up to Nov. 30, 1918, indicate that the highest rate of production of all grades of ore was attained during the third quarter of 1918 and that shipments declined rapidly after the armistice was signed. During 1917 the quarterly rate of production of ore containing more than 35 per cent. of manganese reached a maximum of 50,906 tons in the third quarter, and the total production for the year was 128,053 long tons. In 1918 the rate of production continued to rise, reaching 90,738 tons in the third quarter, and the final total for the year was 304,366 tons. Shipments of ore containing 10 to 35 per cent. of manganese attained the maximum of 283,180 tons in the third quarter of 1918, and the final total of shipments for the entire year was 898,332 tons, not including the manganiferous zinc residue of the New Jersey Zinc Co.

The increase in the shipments of high-grade ore during the third quarter of 1918 is almost entirely to be attributed to the increase in the output of the mines of the Philipsburg and Butte districts, Montana, for the shipments from every other state, except Georgia and Tennessee, were less for the third quarter than the maximum, which in most districts was attained during 1917 or early in 1918. The shipments from the Philipsburg district steadily increased from 1916, when the manganese deposits there were first exploited, to the third quarter of 1918, when 35,998 tons of ore was shipped. The first shipments from the Butte district were made in 1917, and the output of that district during the third quarter of 1918 was 24,097 tons.

As most manganese deposits are exploited by surface workings, and lack good transportation facilities, and as the concentrating mills at many others require an abundant supply of water, the rate of shipment varies with the season, a fact which, considered in connection with the railroad embargoes that prevailed early in 1918, explains the relatively low rate of shipment during the first quarter of 1918 from California, Virginia, Arkansas, and Georgia.

The shipments of low-grade ore from the Cuyuna district, Minnesota, during the third quarter of 1918, were 329,416 tons, the highest on record, whereas those from the Leadville district, Colorado, were 19,859 tons, which shows a great decrease from the maximum, 31,000 tons, shipped in the first quarter of 1918.

Imports.—The total imports for 1918 were 491,303 long tons, valued at $15,095,867, as compared with 629,972 tons valued at $10,262,929 in 1917, a reduction of 47 per cent. in quantity, but an increase of nearly 15 per cent. in value, which amounts to an increase of over 88 per cent. in the value per ton.

Importations of manganese ore from Asia and Australasia were

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by ruling of the War Industries Board prohibited as to ocean shipments made on and after July 20, 1918; and, to make this ruling effective, all outstanding licenses for the importation of manganese from those countries were revoked as to ocean shipment on and after that date.

UNITED STATES PRODUCTION AND IMPORTS
(Long tons)

Year.	Ore.			Ferromanganese.			Spiegeleisen.	
	Imports. (b)	Production. (b)	Production. (c)	Imports.	Av. Value per Ton. (a)	Production.	Imports.	Production.
1909...	212,765	1,544	843,689	88,934	$38.19	82,209	16,921	142,831
1910...	242,348	2,258	619,735	114,228	37.99	71,376	25,383	153,055
1911...	176,852	2,457	522,357	80,263	37.56	74,482	20,970	110,236
1912...	300,661	1,664	868,501	99,137	39.41	125,378	1,015	96,346
1913...	345,090	4,048	672,146	128,070	44.37	119,496	77	110,338
1914...	283,294	2,635	445,827	82,997	41.33	106,083	2,870	79,935
1915...	313,985	9,709	801,290	55,263	60.31	146,542	200	93,282
1916...	576,321	26,966	548,803	90,928	101.62	221,532	*Nil.*	194,002
1917...	629,972	114,216	1,103,503	45,381	134.58	257,842	*Nil.*	188,852
1918...	491,303	304,366	1,356,756	27,168	156.75	345,306	*Nil.*	249,002

(a) At foreign port, no freight or duty. (b) High-grade manganese ore. (c) Manganiferous ore, not including manganiferous zinc ore.

The following table shows the receipts from the principal sources of supply, in long tons:

	Cuba.	Brasil.	Russia.	India.
1905.....	.....	114,670	24,650	101,030
1906.....	.....	30,260	13,805	154,180
1907.....	.....	52,922	1,000	95,300
1908.....	.....	17,150	250	143,813
1909.....	.....	35,600	14,486	145,140
1910.....	.....	53,750	33,120	140,965
1911.....	.....	41,600	19,103	106,780
1912.....	.....	81,580	83,334	128,645
1913.....	.....	70,200	124,337	147,587
1914.....	.....	113,924	52,681	103,583
1915.....	5,141	268,786	.....	36,450
1916.....	30,563	471,837	.....	51,960
1917.....	44,511	512,517	.....	48,975
1918.....	82,974	345,877	.....	29,275

Prices.—After long negotiations, the War Industries Board, the Ferroalloys Committee and the American Iron and Steel Institute were able to agree upon a schedule of prices for the manganese ores produced in the United States. The official announcement, issued by the War Industries Board, effective May 28, 1918, was as follows:

The following schedule gives domestic metallurgical manganese ore prices per unit of metallic manganese per ton of 2240 lb. for manganese ore produced and shipped from all points in the United States west of South Chicago, Ill. This schedule does not include chemical ores as used for dry batteries, etc. The prices are on the basis of delivery f.o.b. cars South Chicago, and are on the basis of all-rail shipments. When shipped to other destination than Chicago, the freight rate per gross ton from shipping point to South Chicago, Ill., is to be deducted to give the price f.o.b. shipping point.

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SCHEDULE FOR ORE CONTAINING WHEN DRIED AT 212° FAHRENHEIT

Metallic Manganese, Per Cent., Inclusive.	Price, per Unit.	Metallic Manganese, Per Cent., Inclusive.	Price, per Unit.
35 to 35.99	$0.86	45 to 45.99	$1.12
36 to 36.99	0.90	46 to 46.99	1.14
37 to 37.99	0.94	47 to 47.99	1.16
38 to 38.99	0.98	48 to 48.99	1.18
39 to 39.99	1.00	49 to 49.99	1.20
40 to 40.99	1.02	50 to 50.99	1.22
41 to 41.99	1.04	51 to 51.99	1.24
42 to 42.99	1.06	52 to 52.99	1.26
43 to 43.99	1.08	53 to 53.99	1.28
44 to 44.99	1.10	54 and over	1.30

For manganese ore produced in the United States and shipped from points in the United States east of South Chicago, 15 cts. per unit of metallic manganese per ton shall be added to above unit prices. Above prices are based on ore containing not more than 8 per cent. silica and not more than 0.25 per cent. phosphorus, and are subject to silica premiums and penalties: For each 1 per cent. of silica under 8 per cent. down to and including 5 per cent., premium at rate of 50 cts. per ton. Below 5 per cent. silica, premium at rate of $1 per ton for each 1 per cent. For each 1 per cent. in excess of 8 per cent. and up to and including 15 per cent. silica there shall be a penalty of 50 cts. per ton; for each 1 per cent. in excess of 15 per cent. and up to and including 20 per cent. silica there shall be a penalty of 75 cts. per ton. For ore containing in excess of 20 per cent. silica, a limited tonnage can be used; but for each 1 per cent. of silica in excess of 20 per cent. and up to and including 25 per cent. silica, there shall be a penalty of $1 per ton. Ore containing over 25 per cent. silica subject to acceptance or refusal at buyer's option, but if accepted shall be paid for at the above schedule with the penalty of $1 per ton for each extra unit of silica. All premiums and penalties figured to fractions.

Phosphorus penalty: For each 0.01 per cent. in excess of 0.25 per cent. phosphorus there shall be a penalty against unit price paid for manganese of ½ ct. per unit figured to fractions. In view of existing conditions, and for the purpose of stimulating production of domestic manganese ores, there will be no penalty for phosphorus so long as the ore shipped can be used to advantage by the buyer. The buyer reserves the right to penalize excess phosphorus, as above, by giving 60 days' notice to the shipper. The above prices to be net to the producer; any expenses, such as salary or commission to buyer's agent, to be paid by the buyer. Settlements to be based on analysis of ore sample dried at 212° F. The percentage of moisture in ore sample as taken to be deducted from the weight.

Payments: 80 per cent. of the estimated value of the ore (less moisture and freight from shipping point) based on actual railroad scale weights, to be payable against railroad bill of lading with attached certificates of sampling and analysis of an approved independent sampling chemist. Balance on receipt of ore by buyer. Actual railroad scale weights to govern in final settlement. Cost of sampling and analysis to be divided equally between buyer and seller.

MANGANESE IN THE UNITED STATES

Arkansas.—The north Arkansas manganese district is situated to the north of the city of Batesville, which is a station on the line of the Missouri Pacific between Newport and Joplin, and it is reached direct either by way of St. Louis or from Kansas City. It has the advantage of being nearer Chicago than any of the Western manganese districts. Lying

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chiefly in Independence County, there are some 150 square miles of the southern Ozark uplift in which manganese occurs in a belt roughly 18 miles long and from six to eight miles wide. Throughout this area it is to be found as a residuum resulting from the decay of certain shales and limestones, wherever conditions were favorable for such decay and the deposition of the ores freed from those rocks. There is close similarity to the districts of central Alabama, northwestern Georgia, and elsewhere in the South where residual deposits of limonites occur.[1]

The production of the region was 7731 tons of high-grade and 9173 tons of medium-grade ore in 1918.

High-grade manganese ores have been mined in the Batesville region at different times since 1850, but mainly during two periods, one beginning in 1881 and ending in 1902 and the other beginning in 1915 and still in progress. The total production of high-grade manganese ore from 1850 to 1918 inclusive was 72,992 tons. In addition, 70,503 tons of ferruginous manganese ore have been marketed.

The production from nearly every mine has been small. In fact only 11 mines have produced more than 1000 tons of ore. Of this number the mines that have produced mainly or entirely high-grade manganese ore are the Southern mine, 1½ miles No. 30° E. of Cushman; the Montgomery mine, 7 miles east-northeast of Cushman; the Club-house mine, one-half mile north of Cushman; the Brooks Hill mine, 1 mile east-southeast of Cushman; the Cummins Hollow mine, 1¾ miles northeast of Penters Bluff station; and the Searcy mine, 3 miles northwest of Pfeiffer. The Southern mine has made an output of 36,000 tons of high-grade ore—more than half the output of high-grade ore from the region. The mines that have produced mainly or entirely ferruginous manganese ore are the Cason mine, 3 miles northeast of Batesville; the Blue Ridge mine, 1½ miles northeast of Cushman; and the Ball mine, 6 miles northeast of Pfeiffer. Of these the Cason mine has produced by far the greater part of the ferruginous manganese ore mined in the region. The Ball mine produces an ore that contains more manganese and less silica and iron than that produced by the other mines that are working ferruginous manganese ore.[2] In 1918 there were 21 shippers of the high-grade and 19 of the medium-grade ore.

California.—The shipments of ore from California for 1918 were 24,067 tons of high-grade ore, against 12,730 tons of this grade in the year 1917. There were 56 shippers. The Livermore-Tesla district, in Alameda and San Joaquin counties, is the source of most of the ore shipped; but large shipments are regularly made from the Chocolate

[1] D. E. Woodbridge, *Eng. Min. Jour.*, Oct. 12, 1918.
[2] U. S. Geol. Surv.

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mountains, Imperial County, and from the Ironwood district, Riverside County.

Colorado.—Much of the State's output comes from the manganese-silver ores of the Leadville district. Metallurgical or 40-per cent. manganese ore is rare in Leadville, though 30-per cent. ore exists in large quantities. The U. S. Geological Survey has recently estimated that 13 deposits in the district named contain about 700,000 tons and possibly 1,500,000 tons of ore averaging 20 to 25 per cent. Mn, 24 to 30 per cent. Fe, and 10 to 15 per cent. SiO_2. Similarly at Red Cliff, Col., two deposits are estimated to have probably 750,000 tons and possibly 1,000,000 tons of ore analyzing 14 per cent. Mn, 38 per cent. Fe, and 1 to 2 per cent. SiO_2, all these ores being low in phosphorus.

The Leadville district mines have available 150,000 to 200,000 tons of manganiferous ore running from 15 per cent. to 43 per cent. manganese, and low in silica and phosphorus; some also carrying up to 50 per cent. iron. Such ores have been shipped to Eastern markets, and used in making ferromanganese carrying 35 to 45 per cent. manganese. Much of this ore may be classed as blocked out, and under normal conditions could be shipped within about a year. The producers in the district have endeavored to increase production wherever possible, and through the sudden ending of the war have incurred a loss of about $200,000. Large bodies of ore have also been developed in the Gunnison district, and much money has been expended, but the operators have not had a chance to ship a carload. It is estimated that from 75,000 to 100,000 tons of ore suitable for ferromanganese has thus been made available there.[1]

In 1918 the Leadville district shipped 3200 tons of high-grade ore and 94,576 tons of 10 to 35-per cent. ore. Other districts of the State shipped 76 and 27 tons of these grades, respectively. In addition, Colorado produces a large amount of low-grade fluxing ore.

Georgia.[2]—The deposits of manganese ore in the Cartersville district, Ga., occur in a belt, 1 to 3 miles wide and 18 miles long, on the east side of the Coosa Valley, at the base of and on the western slopes of the hills that form the western margin of the Piedmont Plateau. This belt is in the eastern part of Bartow County, and the city of Cartersville is on its west side near its south end.

The high-grade ore of the Cartersville district, as shown by the average of analyses of about 1600 tons of material shipped within the last few months, contain about 42 per cent. of manganese, 6 per cent. of iron, 6 per cent. of silica, and 0.14 to 0.20 per cent. of phosphorus. The manga-

[1] *Eng. Min. Jour.*
[2] *U. S. Geol. Surv. Press Bull.*

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niferous iron ore of the district, as shown by the average of the analyses of about 300 tons shipped recently, contains about 15 per cent. of manganese, 20 per cent. of iron, 30 per cent. of insoluble material, and 0.17 per cent. of phosphorus. Practically all the ore produced in the district is shipped to furnaces at Birmingham, Ala., for the manufacture of ferromanganese, spiegeleisen, and manganiferous pig iron.

About twenty mines were operated in the district on about 12 manganese-bearing properties. The largest operations were those of the Georgia Iron & Coal Co., which is operating several mines that produce about half the high-grade ore shipped from the district. The Republic Iron & Steel Co. is another large producer. Some old mines are being reopened and much prospecting has recently been done. The production of the district in 1918 was 6679 tons of high-grade manganese ore, 9430 tons of 10 to 35-per cent. manganiferous iron ore, and 1266 tons of 5 to 10-per cent. ore. There were 12 shippers of high-grade ore.

Minnesota.—Ore reserves in the manganiferous iron properties of the Cuyuna amount to 20,000,000 tons, according to an estimate made by the U. S. Bureau of Mines. Classified according to phosphorus content, the tonnage is divided as shown in the following table:

TONNAGE OF MANGANIFEROUS IRON ORE ON CUYUNA RANGE

	Tons Ore.	Per Cent. Dry Mn.	Per Cent. Nat. Mn.	Tons Mn.
Class 1, Phosphorus below 0.1 per cent.....	1,640,000	16.50	14.50	237,500
Class 2, Phosphorus between 0.1 and 0.2 per cent.....	3,330,000	12.10	10.63	366,300
Class 3, Phosphorus over 0.2 per cent.....	14,745,000	8.38	7.08	1,040,000
	19,715,000	9.70	8.28	1,643,800

Of Class 1, 160,000 tons, and 1,670,000 tons of Class 2 have more than 20 per cent. silica content. Besides these reserves, such mines as the Ferro Algoma, and Cuyuna-Mille Lacs have immense tonnages of highly silicious, intimately mixed, manganiferous material, containing about 15 per cent. manganese and less than 35 per cent. silica, and suitable for the production of silico-spiegel.

Montana.—The armistice had the immediate effect of curtailing manganese mining in Montana. The reason for this is the ability of Eastern steel interests to secure transportation of manganese ore from Brazil and Cuba, thus reducing shipments from the West to quantities specified in contracts. The effect of the decreased output will scarcely be noticed at Butte, because of the relatively small number of men engaged exclusively in mining manganese. In the Philipsburg district, however, the situation is much different.

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The Emma mine is the largest producer of manganese ore in the Butte district. It is operated by the Anaconda under a long-time profit-sharing agreement with the owners, the Butte Copper & Zinc Co. The output of this mine during the war was said to be approximately 10,000 tons per month of rhodocrosite, 8000 tons of which was shipped to Eastern consumers, and 2000 to the ferromanganese plant at Great Falls. The yield at present is 2500 tons monthly. It is thought that the ferro plant at Great Falls can be kept operating at its present capacity and compete successfully with foreign ores as far east as Chicago, though it has been temporarily shut down.

The Philipsburg district will probably return to its pre-war basis, because of the lessening demand for Western manganese ore in the East. The Philipsburg Mining Co. has contracts for delivery of manganese that will keep it busy until spring. But several other companies are not so well situated, as they have spent sums on development and new equipment, expecting a continued demand at the Government price, and are now in a fair way to lose on their investment, as they had just reached a profitable basis when the slump came.[1]

Montana's shipments in 1918 were all of high-grade ore, and amounted to 127,415 tons from the Philipsburg district, 72,381 tons from the Butte, and 136 tons from other districts. There were 37 shippers.

New Mexico.[2]—For several years New Mexico has produced manganiferous ores from deposits in the Silver City district. In 1917 it made a small output by exploiting newly discovered deposits and by working old silver mines for manganese ore. Many of the deposits now mined are in the west-central and southwestern parts of the State, near Fierro, in Grant County; in the Lake Valley, Kingston and Hillsboro districts, Sierra County; near Rincon, Dona Ana County; and near Water Canyon, San Acacia, Socorro, and San Antonio, Socorro County.

In 1918 the Silver City district yielded 445 tons of high-grade and 32,832 tons of manganiferous ore. The other districts of the State shipped 2681 tons of high-grade and 475 tons of manganiferous ore.

Oregon.[3]—So far as known, the manganiferous deposits of the Lake Creek district of Oregon are confined within an area of about 150 square miles in the central part of Jackson County, Ore. Data given by the Manganese Metals Co. show that the ore so far mined has averaged about 20 per cent. Mn. Car samples of two shipments of concentrate ran 47.5 and 48.5 per cent. Mn.

About 1500 tons of ore, containing at least 15 per cent. Mn, is in sight. In addition, incomplete prospecting by drilling and open cut-

[1] *Min. Sci. Press.*
[2] U. S. Geol. Surv.
[3] *Eng. Min. Jour.*, Nov. 16, 1918.

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ting indicates that at least four acres are probably underlain by 10 ft. of ore (about 120,000 tons) containing probably 10 per cent. Mn. The surface indications in other parts of the district warrant an estimate that they may yield 130,000 tons more of material carrying at least 10 per cent. Mn, so that the probable reserves of ore of this grade total at least 250,000 tons.

Tennessee.[1]—Production from Tennessee has, until recently, amounted to only a trifling tonnage of manganese ore. This is due to rather low manganese and relatively high phosphorus content. Though known to exist for a long time, the deposits had been lying idle until war demands and high prices suddenly stimulated search and production, which became particularly active in the three eastern counties, Unicoi, Carter, and Johnson. A number of washing plants have been erected, and production, though relatively small, continued to increase until the armistice was signed.

The Southern Manganese Corporation is the largest operator, having had seven producing mines in the district. In March this company started work on its No. 1, No. 2 and No. 3 mines in Scotia Valley, Unicoi County, and built a fairly complete treatment plant for its No. 1 and No. 2 mines, the plant being provided with log washers, grizzlies, trommels, picking belt, and Harz jigs. No production was made until October, when 140 tons was shipped. Here, as generally throughout the district, the manganese lies upon limestone beneath a decomposed quartzite, which is scraped off so that the ore may be removed from open pits.

Northward, at a distance of about four miles, on the northern slope of Little Mountain, in Carter County, the Max Mining Co., of Braemer, Tenn., has done some development. Here the ore, in the form of small grains to lumps weighing as much as 400 lb., is mixed with clay. It is estimated that there is about 15 per cent. of high-grade ore in the clay bed, which is approximately 40 ft. thick. The lateral extent of this bed has not yet been determined.

At Valley Forge, a plant with four log washers shipped five cars of ore running over 40 per cent. manganese. On Pond Mountain a one-log washer shipped 11 cars of ore. At Blue Springs, Carter County, a two-log washer shipped two cars of ore. At Butler, there were mined and shipped between 25 and 30 cars of ore.

In the Mountain City district the Southern Corporation installed a two-log washer at the Doe Valley mine and shipped 360 tons of ore carrying 22 to 52 per cent. manganese concentrated from ore carrying about 6 per cent. of manganese. The same company has shipped 550 tons of

[1] H. V. Maxwell, *Eng. Min. Jour.*, Jan. 18, 1919.

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ore from Taylors Valley, where it has had about 100 men at work. It has also shipped 550 tons from Shady Valley, where there had been installed a complete washing plant with a capacity of 35 tons per day. From the Neeley the corporation has shipped 63 tons of high-grade ore without washing.

The following table gives a summary of the shipments from the Eastern Tennessee district made during 1918, all of which was in the form of washed concentrates excepting that from the Neeley mine, which was hand-sorted ore.

EASTERN TENNESSEE MANGANESE SHIPMENTS, 1918

Locality.	Shipment.	Per Cent. Mn.	Per Cent. Fe.	Per Cent. SiO_2.	Per Cent. P.
Scotia Valley	140 tons	26.0	20.0	13.0	0.15
Winters Mine	2 cars	.....	.....	.....	.....
Winters Mine boulders	.....	58.59	0.55	4.35	0.14
Valley Forge	5 cars	40.0	.....	.....	.....
Pond Mountain	2 cars.	47.83	7.97	4.50	.....
Pond Mountain	9 cars	46.76	11.96	4.63	0.22
Blue Springs	2 cars	45.0	.....	.....	.....
Butler	28 cars	45.0	.....	.....	.....
Doe Valley	360 tons	22 to 52	2 to 14	2 to 25	.....
Taylors Valley	550 tons	25 to 45	2 to 5	18 to 30	0.15
Shady Valley	550 tons	25 to 46	6 to 12	6 to 15	0.20
Neeley Mine	63 tons	49.0	.....	.....	.....

Utah.[1]—Manganese ores were shipped during the first 10 months of 1918 from the Homansville section of the Chief Consolidated, in Tintic; by various properties in West Tintic, among which was the Liberty Manganese company; also from Green River, Utah, by the Needles Mining Co.; and by Hanawalt Bros., of Denver, who shipped most of the Utah output. The Stewart & Snyder lease and the Triangle lease of the Michigan-Utah, at Alta, shipped manganese ore carrying 42 per cent. and over. The Ophir Hill Consolidated shipped 44-per cent. manganese ore. A few cars were shipped from near Monroe and Marysvale, in the southern part of the State. Practically all of the manganese ore was shipped East. Production was discontinued soon after the signing of the armistice in November, on account of market conditions.

Virginia.—Virginia has more known deposits of manganese than any other state in the Union and more localities have been worked and more manganese has been produced than in any other state. Deposits of manganese occur in the Coastal Plain, Piedmont, and the Mountain (Valley) districts. The production of Coastal Plain area is comparatively small, and only a few deposits have been worked. Those near City Point, in Prince George County, are the most prominent, although only a small production may be expected from this field. Workable deposits of manganese have been found in Albemarle, Amherst, Appo-

[1] E. R. Zalinski, *Eng. Min. Jour.*, Jan. 25, 1919.

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mattox, Buckingham, Campbell, Nelson, Pittsylvania and Spotsylvania Counties, in the Piedmont area. Some of the mines in these counties are yielding a considerable amount. They have been operated for many years and are now in a favorable position to double their production in a short time. The Mountain (Valley) district includes the valley proper, and the area west of the valley known as Appalachia. The principal ore belt lies along the western base of the Blue Ridge Mountains and has a length of 300 miles. The 13 counties in this belt have all produced manganese, the famous Crimora mine having shipped more than all the other mines in the United States combined. Another heavy producer in this district is the Kendall and Fleck mine, situated near the town of Elkton.[1]

War conditions have made it possible and profitable to reopen several manganese mines in Virginia, and many of the operators have realized good profits on small original investments. One of these is the old Paddy's Run mine, at present generally known as the Nelson, situated on a conical-shaped hill in the southwest corner of Frederick County, a few miles from the postoffice of Star Tannery. The nearest shipping point is Capon Road, a station on the Baltimore & Ohio Ry., and 14 miles from the mine.

Old records show that the property was operated in 1832, although the length of operation and production at that time are unknown. Considerable development was done in 1882, and for a period of seven years the mine was actively worked and produced from 2000 to 3000 tons of ore ranging from 45 to 52 per cent. manganese.

After closing down in 1889, the property remained idle until 1915. Some prospecting by Charles M. Nelson confirmed his opinion that large quantities of high-grade ore could be profitably mined, so he reopened the mine in a small way, and shipped several carloads of ore of the following grades:

ANALYSIS OF VIRGINIA NELSON MINE MANGANESE-ORE SHIPMENTS

Type.	Per Cent.				
	Moisture.	Iron.	Silica.	Phosphorus.	Manganese.
Hard blue ore	1.57	0.85	1.08	0.227	52.67
Fine soft blue ore	1.60	3.25	5.43	0.257	50.28
Hard black ore	1.58	3.25	7.05	0.226	48.34
Black ore	5.46	1.30	2.05	0.284	49.18
Fine soft black ore	7.65	4.50	5.55	0.261	48.03

Early in 1917 the property was purchased by mining men, who have installed a complete plant and are now shipping a large quantity of high-grade ore.[2]

[1] M. Haney, *Eng. Min. Jour.*, Sept. 28, 1918. [2] M. Haney, *Eng. Min. Jour.*, Oct. 19, 1918.

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The manganese ore deposits in Virginia formerly owned by the Crimora Manganese Corporation, Crimora, Va., were recently sold to the American Chemical & Industrial Companies, Philadelphia. The new company made important changes in the method of handling and concentrating the deposits and is able to turn out at least 75 tons per day.[1]

Washington.—There are several occurrences of manganese of minor importance in Washington, including an area in Mason County, outcrops on the South Fork of the Skokomish River, the Tubal Cain mine, on Copper Creek, about 25 miles northeast of these, and the Triple Trip mine on the North Fork of the Skokomish River.[2]

WORLD'S PRODUCTION OF MANGANESE ORE (*a*)
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Bosnia. (*b*)	Brasil. (*d*)	Canada.	Chile. (*d*)	Cuba.	France.	Germany.	Greece.	India.
1904	15,460	485	1,114	208,260	123	2,324	33,152	11,254	52,886	8,549	152,601
1905	23,732	*Nil.*	4,129	224,377	22	1,323	(*d*) 8,096	6,751	51,463	8,171	250,788
1906	20,577	120	7,651	121,331	84	35	(*d*) 13,997	11,189	52,485	(*d*) 9,200	579,231
1907	24,954	2,100	7,000	236,778	1	(*c*)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	*Nil.*	1	1,492	15,865	67,692	10,750	685,135
1909	29,966	6,270	5,000	240,774	*Nil.*	(*c*)	2,976	9,378	77,177	5,374	654,974
1910	28,964	*Nil.*	4,000	253,953	*Nil.*	(*c*)	(*c*)	7,925	80,559	41	813,761
1911	30,713	*Nil.*	3,600	213,000	5	(*c*)	(*c*)	6,036	87,297	733	681,015
1912	23,306	*Nil.*	4,650	154,870	68	(*c*)	(*c*)	5,576	92,474	7,719	643,209
1913	35,549	*Nil.*	4,700	122,300	*Nil.*	(*c*)	(*c*)	7,732	330,797	556	828,089
1914	(*f*) 11,413	*Nil.*	4,120	183,630	25	(*c*)	(*c*)	(*c*)	(*c*)	558	693,824
1915	(*c*)	500	(*c*)	288,671	182	(*c*)	9,145	(*c*)	(*c*)	408	457,668
1916	(*c*)	3,870	(*c*)	503,130	868	(*c*)	33,653	(*c*)	(*c*)	3,600	655,592
1917	(*c*)	2,020	(*c*)	532,855	143	(*c*)	(*e*) 35,000	(*c*)	(*c*)	(*c*)	600,325

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom.	United States.
1904..	2,836	4,324	199	(*c*)	843	430,090	18,732	2,297	8,880	3,197
1905..	5,384	14,017	55	(*c*)	1,541	508,635	26,020	1,992	14,582	4,184
1906..	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	7,032
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	5,694
1908..	2,750	11,130	*Nil.*	.....	1,403	362,303	16,945	4,616	6,409	6,243
1909..	4,700	8,708	6	.....	613	574,938	7,827	5,212	2,812	1,614
1910..	4,200	11,120	5	.....	805	(*d*) 668,050	8,607	5,752	5,554	2,294
1911..	3,515	9,787	1	6	1,000	(*d*) 584,000	5,607	5,377	5,067	2,497
1912..	2,641	12,060	*Nil.*	6	313	(*d*) 766,000	19,936	5,101	4,237	1,691
1913..	1,622	2,313	*Nil.*	*Nil.*	27	1,171,000	21,594	4,001	5,480	4,113
1914..	1,649	17,076	*Nil.*	*Nil.*	6	737,300	(*c*)	3,643	3,496	2,677
1915..	12,577	25,870	*Nil.*	(*c*)	203	(*g*) 31,980	14,328	7,607	4,716	9,865
1916..	18,147	7,874	*Nil.*	(*c*)	653	(*g*) 120,000	14,178	8,894	5,223	27,431
1917..	24,532	51,366	(*c*)	(*c*)	21	(*c*)	57,474	19,873	10,104	124,244

(*a*) Official statistics. (*b*) Includes Hersegovina. (*c*) Statistics not available. (*d*) Exports. (*e*) Estimated. (*f*) Hungary. (*g*) Shipments from Tchiaturi district; mostly held at port for lack of shipping.

Wyoming.—Few deposits of manganese ore are known in Wyoming. A deposit in the northern part of Albany County has been exploited by the Wyoming Manganese Co., of Laramie. At the time the deposit was visited no ore had been shipped, although about 200 tons of ore containing 40 per cent. Mn was on the dumps. Late in 1917 about 30 tons of high-

[1] *Iron Age*, Feb. 20, 1919.
[2] *U. S. Geol. Surv. Press Bull.*

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grade ore was shipped to a mill at Boulder, Colo., for experimental purposes. The development work consisted of 200 ft. of tunneling connecting with a shaft 25 ft. deep.[1] In 1918 shipments were made of 92 tons, half of it high-grade.

Foreign Countries

Australia.—Two deposits of manganese ore have recently been examined at Kandanga, Queensland, one at the Bollier mine, to the west of the Coonan-Gabber Creek about four miles to the east of the Mary River Railway, in the parish of Brooloo; the other in the parish of Imbil, to the south of Kandanga Creek and about three miles to the west of the railway line.

The deposits, with several others in this area, occur in a well-defined belt of manganese-bearing country, mostly made up of slates, schists, quartzites, and jasperoids, which lies parallel to a long belt of serpentine to the west and extending northwesterly to beyond Kilkivan and southeasterly to Kilcoy, Fernvale, and Pine Mountain, near Ipswich.

From the Kandanga lode, consignments, amounting to 115 tons, have shown the following analysis: moisture, 4.6–6.6 per cent.; Mn, 44–46.2; Fe, 1.8; P, 0.096–0.098; SiO_2, 18.5–25.5 per cent.

The total Queensland production in 1918 was 1350 metric tons, valued at £4151.

Brazil.—The manganese situation of Brazil is very interesting, as this country is the largest supplier of this mineral, so essential in the manufacture of steel and munitions of war. Exports during 1917 were greater than during any previous year and amounted to 532,855 metric tons, all of which was shipped to the United States. Figures for the 1918 production are 393,388 tons, doubtless all shipped to the United States, as in 1917. The following table shows the exports for several years past:

Year.	Metric Tons.
1910	252,958
1911	173,941
1912	154,870
1913	122,300
1914	183,630
1915	288,671
1916	503,130
1917	532,855
1918	393,388

The average price of the ore increased during this period to about five times its normal level, mostly in 1916 and 1917.

The reason for the diminished exportation as compared with 1917 is largely attributable to the difficulties of transportation over the Central

[1] *U. S. Geol. Surv. Press Bull.*

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Railway, which carries all of the ore from the centers of production in the State of Minas Geraes to Rio de Janeiro, the principal port of exportation.

Central America.—An American syndicate commenced early in 1916 to ship manganese ore to the United States from the Mandinga mines, about 70 miles east of Colon, Panama. In spite of the difficulty in getting transportation, some 18,000 tons has been shipped and 4000 tons awaits shipment from the mines. This syndicate has taken steps to obtain a concession to mine manganese ore at a place 12 to 15 miles south of Porto Bello, on the Boqueron, a branch of the Chagres river. This deposit appears to be extensive, and if on further investigation the ore is found in sufficient quantities and of a marketable grade mining will be undertaken if the syndicate feels warranted in going to the expense of putting in some sort of conveying system to transport the ore to the port of Porto Bello, about 20 miles east of Colon, for shipment to the United States.[1]

Interest in the manganese field in the Guanacasta section of Costa Rica was stimulated by increased demand, although the addition in production was not maintained at the rate indicated by the expansion of operations after the first exports were made in 1916.

Cuba.—Manganese ore is found in Cuba in Oriente, Santa Clara, and Pinar del Rio provinces; in Oriente Province the deposits are in three areas, one north and northeast of Santiago de Cuba, another south of Bayamo and Baire, and the third on the Caribbean coast, near Portillo. The first two include the only extensive deposits on the island. In Santa Clara Province a little ore has been found near the Caribbean coast west of Trinidad, and in Pinar del Rio Province small deposits occur north of the city of Pinar del Rio and further west near Mendoza. The two areas in Oriente Province promise considerable production.

The production of manganese ores in Cuba during 1918 amounts to an estimated total of 95,000 tons, as compared with 35,000 tons for 1917. The number of new properties opened up in 1918 was relatively small, although they yielded 40,000 tons in that year. Improved equipment resulted in adding 23,600 tons to the output of washed ores, formerly produced only by Aguilera & Co., Ponupo; and the only concentrating plant installed has placed the Cauto Mining Co. second in the list of producers, with about 12,000 tons shipped. Thus, the total of washed and concentrated ores now amounts to practically 75 per cent. of the total output. The importance of this method of treatment should become manifest to those interested in the future of manganese mining in this field. Although the average grade of the washed product has

[1] *Comm. Rept.*, July 20, 1918.

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been 4 to 6 per cent. lower than that of the shipments of unwashed ores, the benefits to be derived by some form of treatment are obviously those due to the increased production and the corresponding reduction of costs below anything attainable by the smaller operators, who have felt that they could not afford new equipment.[1]

Ecuador.—Manganese deposits are being worked near the town of San Antonio, Province of Pichincha, Ecuador. The principal orebody is a blanket deposit 3 to 9 ft. thick. The ore resembles gravel in appearance, and assays 46.36 per cent. Mn, with a little copper and phosphorus. Silica is only 6.4 per cent. The altitude of the property is 7874 ft., and the district is wholly volcanic, partly covered by sand. Native laborers receive from 20 to 50 cts. per 10-hr. day. Quito is 28 miles distant. Mule carriage to rail at that place is 68 cts. per 220 pounds.[2]

Egypt (By R. H. Graves).—The manganiferous ore deposits of Egypt occur on the Sinai Peninsula, principally in the district 10 to 15 miles inland from the shores of the Gulf of Suez and the harbor of Abu Zenima. (Lat. 29° North and long. 33°21′ East.) The topography of this part of the country is a mass of hills and ravines formed by the erosion of a plateau 2000 ft. above sea-level.

The ore-bearing rocks belong to the Carboniferous series, which here consists of two sandstones divided by a bed of limestone or dolomite. These Carboniferous rocks lie unconformably on the eroded surface of ancient schist, gneiss and granite. The formation has undergone considerable faulting, which has a direct bearing on the occurrence of the manganese and iron ores found at the junction of the limestone and the lower sandstone. These ores exist both as pockets and as a horizontal bed varying from a few inches to several feet in thickness.

Mining facilities in the Sinai Peninsula are not unfavorable when compared with other parts of the world. Adequate labor can be obtained and its cost is reasonable. Water is scarce, but can be shipped economically from Suez. Mining exploitation has been delayed by war conditions and the district passed for a short time into enemy occupation.

The Sinai Mining Co. is the only operator which has yet reached the productive stage. Its mines are connected with the seaboard by 6 miles of aerial ropeway and 11 miles of railway which terminates at the harbor of Abu Zenima, where storage ore-bins and mechanical loading facilities have been installed.

The ore varies from a pure manganese ore to an almost pure iron ore, the bulk forming a manganese-iron ore averaging Mn 35.0 per cent., Fe 23.0, SiO_2 2.95, P 0.136 per cent. Higher grades can be obtained

[1] J. B. Stewart, *Eng. Min. Jour.*, Jan. 25, 1919.
[2] *Comm. Rept.*

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by selection and recent shipments have assayed Mn 40.41 per cent. and Fe 16.31 per cent.

The production for the year 1918 was 27,498 metric tons, of which only 9455 tons could be exported, owing to the difficulty of obtaining shipping.

India.—There was a decrease in the manganese output in 1917 to 590,813 long tons, as compared with 645,204 tons in 1916. This is a falling off of 8.5 per cent. The shortage of tonnage continued, but the special arrangements made by the Government for shipping, as in 1916, went far to relieve it. Prices advanced still further, and the average rate per unit for the year was $0.75, which was a distinct advance on the $0.59 average for 1916.[1]

Mexico.—Manganese in Mexico is associated with silver in the States of Puebla, Chiapas, and Lower California, while in Chihuahua it is found with Cretaceous limestones, as pyrolusite, psilomelane, wad, and porphyry rocks. In a zone of about 20 miles around Chihuahua City the Cretaceous geological formation predominates and in their limestones manganese is present with iron and small quantities of gold, especially in the small chains of mountains north and northwest of this city.

The first shipments were made in September, 1917, and in October, 1918, about 350 tons was being exported monthly to the United States. The ore shipped averages 40 per cent. manganese, some running as high as 48 per cent.

Russia.—Reports from the Caucasus indicate that the manganese mines there are practically stopped, the miners demanding outrageous wages owing to the high cost of living and the depreciation of the rouble. The stocks of ore at Batoum and Tiflis were commandeered by the Turks and sold by them to Germany, but there is a fair quantity in Poti available for shipment. An odd cargo or two may get through, but permits are necessary for the passage of the Dardanelles, and food and other essential requirements receive first attention, hence it will be a good time before free chartering can be resumed. Consumers in Great Britain who formerly depended on the Russian ores are now drawing from India and Africa, while shipments to the United States have been replaced by Brazil.[2]

South Africa.—The manganese output, recorded in the table for 1917, came partly from a vein deposit in the Magaliesberg quartzite, near Derdepoort, and partly from an occurrence which is being exploited on the farm Daniels Rust, 12 miles north of Krugersdorp. Here the manganese occurs as nodules, up to 12 in. in diameter, composed of a mixture of pyrolusite and psilomelane. These are scattered indiscriminately through residual clay, resulting from the weathering of the dolomite of the Transvaal system. The nodules average about 47 per cent.

[1] *Comm. Rept.*, Jan. 29, 1919.

[2] *Metal Bull.*, Feb. 14, 1919.

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of metallic manganese. The deposits appear to be of considerable extent, and can be cheaply worked. A somewhat similar occurrence is being opened up at Rand Gate, near Randfontein. At this locality, however, the manganese content of the nodules is lower than at Daniels Rust. A promising deposit has also been discovered on the property of the Randfontein Central Gold Mining Company.[1]

An important discovery of manganese has been made near Pretoria, Transvaal.[2] The lode is 4 ft. wide, and has been traced so far for 300 yards, outcropping. The content is 80 per cent. manganese oxide. Rights over the property have been secured by Johannesburg interests.

Turkey.—According to reports from Constantinople there is now unusual activity in developing the mineral resources of both European and Asiatic Turkey. Concessions have been obtained lately by Turkish subjects to develop manganese deposits at Kütshük, in the sandjak of Menteché; by a German subject to work a manganese mine at Inludja, in the sandjak of Menteché; and by an Austrian to open up a manganese mine near Kapakli-Kapus-Dere, also in the Sandjak of Menteché.

Uruguay.—While traces of manganese are found practically all through Uruguay, they are mostly small and poor in quality, and the lack of transportation facilities and timber contributes to discourage further exploitation. The only manganese deposit being worked on any scale, so far as present information goes, is at Pantanoso, near Montevideo. Ore is reported to have been extracted at a depth of 90 ft., and some 16 tons was exported in the first eight months of 1918. It has been estimated that about 80,000,000 tons of ore could be taken out from one of the principal deposits in the Department of Rivera, near the Arroyo Zapucay, which is the property of the Uruguay Manganese Co. The analysis shows an average content of 34.8 per cent. Fe, 22.7 Mn, 9 SiO_2, 0.03 P, and 0.05 per cent. S. A plan was put forward to build a 75-mile branch of the Central Uruguay railroad to the deposits, a proposition which aroused considerable interest.

Another property at Carrasco is said to have been examined by representatives of British and German interests, and is now being worked on a small scale, the ore being used by glass factories. Official statistics give the export figures for 1915 as 2 tons of ore, none in 1916, and 1 ton in 1917.[3]

Future Prospects.—While many expect the manganese industry in the United States to revert to practically its pre-war condition as soon as normal industrial conditions are again reached, there has been made the suggestion that it is not advisable that the industry be allowed to

[1] *So. Afr. Min. Jour.*, Feb. 22, 1919.
[2] *South African Mining Review.*
[3] *Min. Jour.*, Mar. 1, 1919.

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fall by the way, leaving the greatest steel industry in the world to revert to a part or entire dependence on foreign manganese. There seems but one remedy for such a possibility—a tariff high enough to meet foreign competition. It has been advocated by prominent interests in the trade, even by some of those who have been sellers of British ferromanganese in the past. Unless some such protection is afforded, it is claimed the British alloy can undersell the American. Almost any reasonable tariff on this alloy would not be a hardship, for the amount consumed per ton of steel is small; but after all, the determinations of the Peace Conference may serve to settle conditions of international trade.

There have been suggestions also of a tariff on manganese ore. Opinion is divided as to whether this is advisable. Supplies of highest-grade ore are ample in Brazil. The cost of production from such ore is low. As compared with most American ores, this is an important consideration, for it is estimated that even when using the best ore a blast furnace can produce only 35 per cent. as much ferromanganese as pig iron. Under the stress of war conditions only about 50 per cent. of the manganese ore needed came from American mines, and these were scattered and operated only under the stimulus of high ore prices.[1]

Ferromanganese and Spiegeleisen

The scarcity of manganese ore suitable for the manufacture of 80-per cent. ferromanganese, and the necessity of bringing a great part of the ore from Brazil, led to the adoption during the war emergency of 70-per cent. ferromanganese instead of the 80-per cent. alloy as the standard. The necessity for this action arose in large measure from the fact that ships could not be spared to transport from Brazil and other places the necessary tonnages of high-grade ore necessary to produce the 80-per cent. alloy.

Working along the same lines, every effort was made to utilize spiegeleisen instead of ferromanganese for the manufacture of higher carbon steels. Meetings of the steel makers of the country were held to encourage the use of spiegeleisen, at which the representatives of several plants who were successfully using the low-grade alloy gave their experiences, which had in the main been satisfactory. In most cases, of course, it has been necessary to install cupolas to melt the spiegeleisen, inasmuch as the large proportions of this alloy that had to be used could not be added cold. This was, of course, a return to the practice of the old Bessemer rail mills and data has been available for years as to the best methods of using these low-manganese alloys.

There have also been manufactured several grades of silico-spiegel

[1] *Iron Age*, Feb. 20, 1919.

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containing both silicon and manganese and during the war the use of this alloy has been considerably extended. There are several objections to its use which have prevented its being adopted as widely as the use of spiegeleisen.

The necessities of the country made it essential that several plants be built for the manufacture of ferromanganese in the electric furnace and had the war lasted a few months longer the total tonnage of electric ferromanganese would have been very considerable. Even as it was, a large amount was turned out and the difficulties incident to the manufacture of the alloy in the electric furnace were largely, if not entirely, overcome.

The domestic output of both ferromanganese and spiegeleisen by the blast furnaces and electric furnaces has steadily grown since 1913. In 1918 the production of 70 to 80-per cent. ferromanganese reached the striking total of 345,306 gross tons, or 28,775 tons per month. This is the largest output of any year in the history of the industry and compares with 257,834 tons in 1917, or 21,486 tons per month, with 208,389 tons in 1916, or 17,365 tons per month, and with 119,496 tons in 1913, or 9958 tons per month. The output of 1918 compared with that of 1913 has therefore been nearly three times as great.

A record was also made in spiegeleisen in 1918. The total for the year of all grades was 249,002 tons, or 20,750 tons per month. The 1917 production was 188,852 tons, or 15,737 tons per month. The December output was 25,528 tons. This exceeds any month in the first half of 1918 and is close to the monthly average for the last half. The lowest output in the last four years was 93,282 tons in 1915.[1]

The increased demand has resulted not only in a heavily increased production from the blast furnace, but also has led to the development of an extensive production in the electric furnace, notably by the Southern Manganese Corp. in Alabama, the Anaconda Copper Co. in Montana, and the Pacific Electrometals Co. in California, besides several smaller installations.

FERROMANGANESE AND SPIEGELEISEN OUTPUT IN THE UNITED STATES—GROSS TONS

	Ferro-manganese.	Spiegel-eisen.	Total.	Average. per Month.
1912	125,378	119,506	244,884	20,407
1913	119,495	126,081	245,576	20,464
1914	106,083	100,365	206,448	17,204
1915	146,542	93,282	239,824	19,985
1916	208,389	197,518	405,807	33,817
1917	257,834	188,852	446,686	37,222
1918	345,306	249,002	594,308	49,525

[1] *Iron Age.*

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Imports.—In 1913 the imports of ferromanganese into the United States were about 7 per cent. greater than the domestic production, or nearly 52 per cent. of the total supply; in 1918 the imports amounted to less than 8 per cent. of the domestic production, or only about 7.3 per cent. of the total supply.

Prices.—Monthly quotations on ferromanganese covering the entire period of the war are given in the following table:

	1913.	1914.	1915.	1916.	1917.	1918.
January	$65.00	$ 36.00	$ 68.00	$110.00	$175.00	Government Control Price, $250.00
February	65.00	38.00	100.00	140.00	210.00	
March	65.00	38.00	100.00	175.00	270.00	
April	65.00	38.00	100.00	175.00	325.00	
May	61.00	38.00	100.00	175.00	400.00	
June	61.00	37.50	105.00	175.00	400.00	
July	58.50	27.50	103.00	175.00	400.00	
August	56.00	100.00	105.00	170.00	375.00	
September	55.00	80.00	110.00	164.00	360.00	
October	50.00	66.00	105.00	160.00	300.00	
November	50.00	68.00	100.00	155.00	250.00	
December	45.00	68.00	100.00	162.50	245.00	

Concentration of Manganese Ores

The following summary of the methods applicable to the concentration of manganese ores is taken from Bulletin 9, U. S. Bureau of Mines War Minerals Investigations Series, by Edmund Newton. A general classification of methods applicable to the manganese industry is given below. These are all preliminary to the greater and final concentration of the desirable elements in the blast furnace from which the ferro-alloy is produced.

Simple Methods of Concentration:

(*a*) Selective mining.
(*b*) Hand picking.
(*c*) Jigging.
(*d*) Screening.
(*e*) Log washing.
(*f*) Water classification.
(*g*) Roughing table treatment.
(*h*) Slime table or vanner treatment.
(*i*) Pneumatic separation.
(*j*) Combination of two or more of the above.

Complex Methods:

(*a*) Magnetic separation:
  1. Without preliminary thermal treatment.
  2. With preliminary thermal treatment.
(*b*) Electrostatic separation.

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(*c*) Hydrometallurgical processes:
1. Leaching with various acids. Precipitation by chemical substances.
2. Leaching with various acids. Precipitation by electrolysis.
3. Leaching with various acids. Evaporation of solution and heat treatment in rotary kiln.

(*d*) Preliminary thermal processes:
1. Drying, to remove hygroscopic moisture.
2. Calcining, to remove carbon dioxide or combined water.
3. Agglomerating fine concentrates to make them desirable for blast-furnace use.
4. Volatilizing manganese at high temperatures in the presence of certain constituents which form readily volatile compounds.
5. Direct reduction of oxides by carbon, under temperature control.

(*e*) Miscellaneous processes:
1. Flotation.
2. Use of heavy solutions.

For a full discussion of the problems involved in the concentration, the reader is referred to the original publication, or to an abstract by the author in *Bull. Am. Inst. Min. Eng.*, No. 146, p. 379, Feb., 1919.

TECHNOLOGY

Ferromanganese Utilization.—An investigation by the U. S. Bureau of Mines[1] indicated that three practices for utilizing our domestic alloys in open-hearth steel practice seem to commend themselves above the others. These are as follows: 1. The use of a "molten spiegel mixture" for deoxidation and recarburization. 2. The practice of melting and refining the steel bath so as to insure a comparatively high residual of manganese content, say 0.3 per cent. Mn. 3. The use of manganese alloys containing silicon.

Experience has shown that the addition to the steel bath of the ferromanganese in the liquid condition instead of as a solid tends to give a more uniform steel, and shortens the time of the heat; the one outstanding advantage is the direct saving in the quantity of the ferromanganese used per ton of ingot, amounting to from 5 to 30 per cent., depending upon the kind of steel being made. Considering the present and recent market prices of ferromanganese, the saving has been from 20 to 75 cts. in the cost per ton of ingot produced. A Swedish authority maintains that Swedish and German experience shows an average saving of 44 per cent. in manganese. In fact, in the whole discussion of manganese conservation not enough has been said of the saving possible from premelting in electric furnaces.

[1] S. L. Hoyt, "The Use of Manganese Alloys in Open-hearth Steel Practice." *Bull.* 11, *War Minerals Investigations Series.*

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Manganese Alloys.—Developments in engineering during the past decade, particularly as applied to marine construction, mining machinery and other purposes in which corrosion offers a serious problem, have created a large demand for a non-ferrous metal highly resistant to corrosion and at the same time useful in general construction work as a substitute for steel without materially decreasing the factor of safety or increasing the weight of the various parts over that ordinarily used in the case of mild steel. To obtain the combination of desired properties many compositions have been proposed and used with excellent success, but at the present time probably the most popular and most widely used combination is the non-ferrous alloy commonly called manganese bronze. This is nothing more than a high brass to which have been added, by the proper method of alloying, comparatively small percentages of aluminium, iron, or manganese with the definite purpose of strengthening the alloy and rendering it more dense and close-grained than the average yellow brass casting.[1]

The war has caused an increasing scarcity of phosphorus and its well-known alloys with copper and tin. At the same time, the production of brass and bronze, nickel-silver, cupro-nickel, and other non-ferrous alloys, has considerably increased. The manufacturers of these products had therefore to secure other materials which would serve their purpose; principally that of a deoxidizer, which could be obtained promptly and regularly, and for this purpose pure carbon-free manganese metal and manganese-copper alloy have been used.[1]

An elaborate study of the magnetic properties of manganese and special manganese steels was made by Robert Hadfield, C. Cheneveau, and Ch. Geneau and published recently in the Proceedings of the Royal Society of London.

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[1] *Bull. Am. Inst. Min. Eng.*

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MICA

By J. Volney Lewis

On account of restricted shipping facilities, and particularly because of the difficulty and uncertainty of imports in the face of strong demand, prices of mica showed a continued upward tendency throughout the year 1918, although perhaps not more so in proportion than other raw materials. A gradual decline in prices is expected as transportation and commercial conditions become more nearly normal, although a return to pre-war prices is not likely to be attained for many years, if ever.

For many years preceding the war this country produced less than 40 per cent. of the domestic consumption of sheet mica. If figures were available for the higher grades, such, for example, as will meet the rigid specifications for high-potential electric purposes, or the requirements of clearness, flexibility, freedom from flaws and color, etc., for many of its uses in glazing, the proportion obtained from domestic sources would undoubtedly fall much lower.

While prices have risen sharply under war conditions, and hence also the total value of the domestic output, there has been only a very moderate increase in the production of the higher grades of sheet mica, the large producing states having done little more than sustain their general average. It is very doubtful, therefore, whether the country is capable of meeting even its normal demands for these grades. At any rate it is not at all likely ever to do so except under much more effective stimulation than was furnished by the recent war conditions.

Sheet mica held an important place among the munitions of war on account of its extensive use in electric appliances, especially in condensers, magnetos, and spark plugs; also as windows in auto goggles, gas masks, and the conning towers of warships and submarines; and as covering for wounds.

North Carolina continues to lead in the domestic production, having furnished 70 per cent. of the total value in 1917, but only 48 per cent. of the sheet mica, according to statistics collected by the United States Geological Survey. New Hampshire was second, with 23 per cent. of the value and 39 per cent. of the sheet mica. Virginia, South Dakota, Georgia, Alabama, Idaho, and Colorado, in the order named, produced much smaller amounts. Complete statistics are not yet available, but it is believed that the principal producing states about held their own in 1918.

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Imports during the war, reduced by shipping restrictions to an average much less than one-half the normal, have continued to come chiefly from India, Canada, Brazil, and Argentina, in descending order, with smaller amounts from Guatemala, Newfoundland, Mexico, Japan, South Africa, Peru, and Costa Rica. Exports of mica from the United States, chiefly manufactures, went in greatest value to Canada, Japan, and the United Kingdom, as in former years, but with Canada greatly predominating in the fiscal year 1917–18.

Idaho.—Heretofore one of the smallest mica-producing states, Idaho furnished 249 tons in 1918, with a value of $10,464. The deposits are at Mica Mountain, in Latah County, where pegmatite dikes up to 20 ft. in thickness occur, and some of the sheets obtained measure as large as 10 by 18 inches. The Muscovite mine has been developed to a depth of over 200 ft. and a length of 500 ft., but work was interrupted by conflicting claims. Another company continued operations with a crew of six men.[1] The district is reported to have produced in former years as much as 50 carloads (of 20 tons each) which turned out 5 per cent. first-class sheets, 15 per cent. second class, and the remainder scrap.[2]

Foreign Mica

India.—During the war the Government has made every effort to increase the output of Indian mica, in order to meet the great demand for munitions. With this object, exports other than to England were prohibited in September, 1915; in May, 1916, a Government agency was organized for the purchase of all mica suitable for munitions at fixed rates; and in March, 1917, prices having risen in the London market, free export to that market was again allowed, and the Government agent confined his activities to requisitioning stocks that were unreasonably withheld upcountry.

Advice and assistance in established mining areas and in searching for new sources of supply was given by members of the Geological Survey. Particularly promising deposits were found in the neighborhood of Nansa, a few miles north of Gangapur, in the belt of pegmatite-bearing schists and granites that runs through the state of Udaipur, and immediate negotiations were begun for opening them up.[3]

The mica output in India was practically stationary, being 4,020,352 lb. in 1917, as compared with 4,029,536 lb. in 1916. There was an increase of about 1,000,000 lb. in the Bihar and Orissa field, but this was offset by an equal decrease in the Madras field.[4]

[1] Rept. State Inspector of Mines, Idaho, 1918, pp. 104, 105.
[2] *Eng. Min. Jour.*, Feb. 1 and May 24, 1919.
[3] *Records Geol. Surv. of India*, **49**, 14 (1917).
[4] *Comm. Rept.*, Jan. 27, 1919.

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India produces about two-thirds of the world's mica supply, and hence is the source of much the greatest volume of imports into the United States. In the fiscal year 1917–18 crude Indian mica to the extent of 376,141 lb., valued at $366,367, and split mica to the value of $614,989, was imported—all of which are a little below the corresponding figures for the preceding year.

Canada.—Mica production in Canada during 1918 had an estimated value of $268,375, as compared with a value of $358,851 in 1917, a decrease of 25.2 per cent.[1] A part of this reduction, at least, would have appeared a year earlier, except for the marketing in 1917 of a considerable stock that had accumulated at one of the mines in former years. Out of five leading producers and nine smaller ones in Ontario, all but the Lacey mine were closed on account of the war.

Imports showed a great falling off in Canadian mica for the fiscal year 1917–18, the figures being 156,805 lb. of crude mica, valued at $45,298, as compared with 438,554 lb., valued at $82,408, in the preceding year. For cut and split mica there was a slight increase in value—$338,204 for 1918 and $326,045 for 1917.

The output of the Lacey mine, near Sydenham, was about 6000 lb. per week of rough cobbed mica. The mine, which is owned and operated by the General Electric Co., was worked on the seventh level, about 185 ft. below the surface.[2]

The mica deposits are located about the contact of the Greenville crystalline limestones with the Laurentian gneisses. According to M. B. Baker,[3] the intrusive Laurentian has formed with the limestone contact metamorphic deposits of pyroxene, scapolite, and apatite. Scattered through this material are pockets and veins of phlogopite mica of a rich amber color and sufficiently free from physical defects to be mined profitably. There are no walls or sharp contact planes and the beds are extremely irregular in shape, rarely appearing anything like a true vein. The deposits are usually made up of pyroxene, phlogopite, apatite, and calcite, named in the order of their crystallization.

Many of the mica deposits are free from calcite and some of them are free from apatite, but all contain pyroxene, hence the erroneous name "pyroxenite," which has been applied to these masses. The more open and spacious contacts have developed the large crystals for which these deposits are famous. Mica crystals 5 and 6 ft. across have been found in both Quebec and Ontario mines. Pyroxene crystals 6 in. square and 18 in. long, apatite crystals 10 in. in diameter, sphene 4 in. in cross-section, zircon half an inch to a side and an inch and a half long, and other minerals

[1] Prelim. Rept. Min. Prod. of Canada, Dept. of Mines, 1918.
[2] *Eng. Min. Jour.*, Jan. 11, 1919.
[3] Rept. Ontario Bureau of Mines, **25**, 28–31.

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of similar dimensions have made these deposits famous collecting ground for mineralogists.

The size of the crystals and therefore the economic value of the mica deposits depends on the openness of the ground in which the crystals grew. There are great areas of dense "mica-rock" which yield no marketable mica. There is no reason why good mica should not follow indefinitely down the contacts where there has been no pressure to deform it physically.

Brazil.—The quality of Brazilian mica is excellent and the production has been rapidly increasing. Thus far the mining has been confined to the states of Minas Geraes, Bahia, Goyàz, and Sao Paulo, where it occurs in pegmatites intersecting the metamorphic schists. The rock is generally decomposed to great depth, so that the books of mica are disseminated through a mass of kaolin. Many of the localities are handicapped by lack of transportation facilities.[1]

Brazil stood second in the value of crude mica sent to the United States in the fiscal year 1917–18, having furnished 108,004 lb., valued at $97,231, as compared with 86,124 lb., valued at $44,164, in the preceding year. In split-mica imports Brazil ranked third, with a valuation of $39,415, as against $10,468 in 1917.

Argentina.—Exploitation of mica in the Argentine heretofore has been only incidental and has not been an established industry, hence there have been great changes in output from year to year. With the high prices of the war there has been an increasing interest, and the production of 1918 was expected to surpass that of 1917. In 1917 the production was 154,805 lb., as compared with 11,257 lb. in 1916, and the destination of the chief exports was as follows: England 71,012 lb.; United States 52,470; Italy 12,099; Spain 2809. The total exports in recent years have been as follows: In 1912, 14,335 lb.; in 1913, 14,178; in 1914, 725; in 1915, none; in 1916, 14,033; in 1917, 139,045.

Mica deposits are known to be numerous, especially in the provinces of Cordoba, San Luis, and San Juan, and in many of these localities sheets of good quality are obtainable. In the first half of 1918 the prices advanced 25 to 30 per cent., owing to the fact that four or five German houses were collecting and holding mica for the purpose of preventing its exportation.[2]

Imports of crude mica from Argentina for the fiscal year 1917–18 were considerably more than double the quantity and nearly treble the value of the preceding year, the figures being 51,605 lb. valued at $29,202 in 1918, as compared with 22,762 lb. valued at $10,530 in the preceding

[1] For details of producing localities, etc., see MINERAL INDUSTRY, 26, 448 (1917).
[2] *Comm. Rept.*, Aug. 14, 1918.

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year. For the first time also cut and split mica was obtained from this source, the valuation being $5043.

Guatemala.—The existence of mica in Guatemala has been known for many years, but not until the advent of the high prices occasioned by the war have the deposits been worked to any extent. During the past two years large quantities of mica, some of it in exceptionally large sheets, have been exported to the United States, and efforts are being made to continue the exploitation of the mineral. Two or three companies are operating.[1]

South Africa.—The most important mica deposits thus far discovered in South Africa are in a belt along Olifants River, southeast of Leydsdorp. The mica occurs in conspicuous veins of coarse white pegmatite, with a prevalent east-west trend, following the southern margin of a great elongated batholith of newer granite—the so-called Palobora granite—intrusive in the older granite, gneiss, and schists of the Swaziland system. Some of the veins are several hundred yards in length and 40 ft. or more across. Systematic mining has been confined to three areas: (1) the neighborhood of Mica Siding on the Selati railway, 22 miles east-southeast of Leydsdorp; (2) the claims of the Union Mica Mines, Ltd., 25 miles east of Mica Siding; (3) the Malelane fields, near the confluence of the Malelane and Olifants Rivers, 75 miles east of Leydsdorp.

There was great activity from 1910 to 1912; numerous claims were pegged, and prospecting was active. This condition was short-lived, however, partly because many veins gave disappointing results, but mainly because of the failure of the producers to find a suitable market, and all activity had ceased by the end of 1916. Within the last two years there has been a revival of interest. Three large companies and several smaller ones are now operating in the belt. One of these employs four white men and 150 natives, and has splitting and grading sheds equipped with modern machines. Experimental shipments have been sent to England, the United States, and Japan.

Mica has been worked on a small scale at Steinkopf, in Namaqualand, and deposits of good quality are also said to have been located close to the border of Rhodesia and Portuguese Africa.[2]

Sweden.—One of the Swedish war industries which is expected to become permanent is the factory for making electric insulating material from mica, which has been started at Gotenborg by John R. Rettig & Co. The company owns mines in the Bohuslän district, where there are large quantities of raw material. It is hoped that the production can be

[1] *Comm. Rept.*, Jan. 31, 1919; *Eng. Min. Jour.*, Jan. 11, 1919.
[2] *So. Afr. Jour. Industries*, April, 1918; *Min. Mag.*, Aug., 1918.

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increased to supply the entire needs of the country, and possibly some also for export.[1]

Queensland.—An extensive belt of mica deposits is reported to have been found at Rifle Creek, west of Cloncurry. Sheets of good size and quality are obtainable, but no mining has yet been undertaken.[2]

Mica Schist for Furnace Lining

Mica schist, which is soft and easily cut into blocks of any desired shape, has been used considerably as furnace lining. It is quarried in eastern Pennsylvania, at places conveniently near the metallurgical plants in which it is used. In 1917 the quantity produced was 39,975 tons, valued at $85,986, an increase of 20 per cent. in quantity and 82 per cent. in value, as compared with the preceding year.[3]

A German Substitute for Mica

Among the many substitutes produced in Germany during the war, a compressed paper product, known as "Pertinax," is claimed to be a useful substitute for mica for electrical purposes. According to a report in Umschau, the peculiarly high insulating qualities of mica are successfully imitated in "Pertinax," its puncture voltage being about 25,000 volts per mm. It is not affected by hot oils, and its tensile strength is 1000 kg. per sq. cm. (14,200 lb. per sq. in.). It can be worked like wood, and is most satisfactory as an insulating material for electrical apparatus and for the manufacture of high-tension condensers and insulators for carrying conductors through partitions.[4]

Statistics of Mica

PRODUCTION OF MICA IN THE UNITED STATES (a)

	Sheet Mica.		Scrap Mica.		Total Value.	Value of Imports.
	Pounds.	Value.	Short Tons.	Value.		
1908	972,964	$234,021	2,417	$33,904	$267,925	$266,058
1909	1,809,582	234,482	4,090	46,047	280,529	618,813
1910	2,476,190	283,832	4,065	53,265	337,097	725,823
1911	1,887,201	310,257	3,512	45,550	355,804	505,552
1912	845,483	282,823	3,226	49,073	331,896	755,584
1913	1,700,677	353,517	5,322	82,543	436,060	947,780
1914	556,933	278,540	3,730	51,416	329,956	629,484
1915	553,821	378,259	3,959	50,510	428,769	692,269
1916	865,863	524,485	4,433	69,906	594,391	1,071,356
1917	1,216,816	708,381	3,250	48,965	757,346	1,430,048
1918(b)	1,644,200	731,810	2,292	33,130	764,940	1,541,129

(a) U. S. Geol. Surv. (b) Sales.

[1] *Comm. Rept.*, Aug. 16, 1918.
[2] *Queens. Govt. Min. Jour.*, June, 1918.
[3] *Press Bull.*, U. S. Geol. Survey, June, 1918.
[4] *Min. Jour.*, Jan. 11, 1919.

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IMPORTS OF MICA INTO THE UNITED STATES[1]

	Unmanufactured.		Cut, Split, and Mfd.		Ground.		Total.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.
1909	1,678,482	$533,218	168,169	$85,595	.....	.....	$618,813
1910	1,424,618	460,694	536,905	263,831	.....	$1,298	725,823
1911	1,087,644	346,477	241,124	155,686	.....	3,389	505,552
1912	1,900,500	649,236	88,632	99,737	.....	6,611	755,584
1913	2,047,571	751,091	46,336[2]	191,924	290,757	4,765	947,780
1914	360,888	168,591	.....[3]	456,805	404,840	4,088	629,484
1915	433,822	240,449	.....	447,962	344,040	3,858	692,269
1916	703,832	421,856	.....	646,080	362,000	3,420	1,071,356
1917	656,391	414,823	.....	1,014,181	92,963	1,044	1,430,048
1918	741,429	658,576	.....	880,906	11,587	1,647	1,541,129

[1] Statistics from Bureau of Foreign and Domestic Commerce.
[2] From Jan. 1 to Oct. 3.
[3] Quantities not reported.

SOURCES OF MICA IMPORTS, 1916–17, 1917–18, YEARS ENDING JUNE 30
(Bureau of Foreign and Domestic Commerce)

	Unmanufactured.				Cut, Split, and Mfd.	
	Pounds.		Value.		Value.	
	1917.	1918.	1917.	1918.	1917.	1918.
India and United Kingdom	462,722	376,141	$379,622	$366,337	$638,247	$614,989
Canada	438,554	156,805	82,408	45,298	326,045	338,204
Brasil	86,124	108,004	44,164	97,231	10,468	39,415
Argentina	22,762	51,605	10,530	29,202	.....	5,043
All others	100	14,151	99	5,221	5,937	809
Totals	1,010,262	706,706	$516,823	$543,289	$980,697	$998,460

EXPORTS OF MICA FROM THE UNITED STATES
(Bureau of Foreign and Domestic Commerce)

	Unmanufactured.		Manufactured.	Total.
	Pounds.	Value.	Value.	Value.
1912	356,601	$14,936	$40,812	$55,748
1913	298,711	14,175	62,184	76,359
1914	467,451	23,145	50,896	74,041
1915	54,183	5,118	39,033	44,151
1916	63,168	4,544	78,671	83,215
1917	.....	.....	.....	74,485
1918	.....	.....	.....	74,529

STATISTICS OF MICA IN CANADA

	Production,[1] Value.	Exports.[1]		Exports to U. S.[2]			
		Pounds.	Value.	Pounds.	Value.	Cut Mica.[3]	Total Value.
1912	$143,796	895,338	$334,054	724,849	$213,750	.....	$213,750
1913	194,304	817,152	240,775	1,277,252	218,365	.....	218,365
1914	109,061	669,163	178,940	679,215	124,785	$42,471	167,256
1915	91,905	879,631	236,124	507,922	69,481	136,700	206,181
1916	122,541	1,308,793	379,720	709,614	79,834	215,340	295,174
1917	218,034	1,198,707	456,671	438,554	82,408	326,045	408,453
1918	268,375	.....	.....	156,805	45,298	338,204	383,502

[1] Canadian Dept. of Mines.
[2] Years ending June 30. Bureau Foreign and Domestic Commerce.
[3] Value reported separately, without quantity, after Oct. 3, 1913.

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MOLYBDENUM

By Alfred W. G. Wilson

The year just passed did not prove so profitable a one to operators as either of the two previous years. The war demand for molybdenum ores or ferro was materially reduced through the collapse of Russia, and some stocks of material accumulated to supply this demand were available for other purchasers. Within the British Empire the fixed price standards were maintained, and practically all the ore available was purchased by agencies acting for the British Government. Available supplies from Norway also seem to have been purchased at high prices. In the United States the market remained strong during January and February, but the release of supplies previously purchased on Russian account or to complete Russian contracts caused a marked decline in price, and for a time ores in storage were unsalable. The home demand was not large enough to absorb the surplus, and most of the small purchasers were forced to close before the end of the year.

The average New York prices, as quoted in the *Engineering and Mining Journal*, were tabulated by Charles Hardy as follows, prices being in dollars per pound for concentrates assaying 90 per cent. MoS_2.[1]

Jan.	$2.233	Apr.	$1.800(a)	July	$1.134	Oct.	$1.000(b)
Feb.	2.150	May	1.250(a)	Aug.	1.000(a)	Nov.	0.875(c)
Mar.	1.901	June	1.250(a)	Sept.	1.106	Dec.	0.850(c)

(a) Nominal. (b) Estimated—no market. (c) No regular market. A few sales reported 87½ @ 85 cents.

Hardy states that the bulk of the stored molybdenite in Pittsburgh and New York was taken up by buyers only at the end of 1918. It was necessary to reduce the price to 85 cts., or practically 40 per cent. of the price which ruled at the beginning of the year, to move these stocks. The larger producers were kept going by the small demand from some of the steel plants.

In Canada the fixed prices as quoted in 1917 and 1918 were maintained. Corresponding prices also prevailed in Australia and other parts of the British Empire.

In 1917 the British Government made contracts for the purchase of almost the entire output of Norway to prevent its reaching the Central Powers. The price is stated to have been at the rate of $4.25 per lb.

[1] *Eng. Min. Jour.*, Jan. 11, 1919, p. 83.

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for 90 per cent. molybdenite concentrates.[1] Similar prices prevailed during most of 1918.

Since the armistice was signed the stocks of molybdenite ore and concentrates in Great Britain have tended to increase, and the amount available is enough to meet all the requirements of the United Kingdom for at least 18 months. It has therefore been arranged to reduce drastically the shipments from outlying parts of the Empire for the purpose of allowing stocks to be realized and to permit the world's market to settle down to a normal working condition as soon as possible. The British Ministry of Munitions has therefore decided to terminate the existing purchasing arrangements at once, and no deliveries of molybdenite loaded on ocean steamers from British oversea ports after April 30, 1919, will be accepted. The Ministry of Munitions further recommends that producers will, in their own interests, take immediate steps to reduce the production of these ores.

Ferromolybdenum was quoted in the United States at $5.00 per lb., on the basis of the molybdenum content, for the first 6 months of the year. In August the price dropped to $4.00 @ $4.50, and closed at $3.50 @ $4.50.[2] In 1918 several hundred tons was produced, chiefly for export to the Allied governments in Europe for use in the production of steel for military purposes. Standard grades are not well established and the alloys offered varied from 50 to 80 per cent. Mo and 1 to 3 per cent. carbon. In Canada two firms were engaged in the production of ferro under the British specifications which required not less than 70 per cent. Mo, maximum carbon content 4 per cent., and sulphur content not over 0.4 per cent. These plants were only operating during a portion of the year and the total production was slightly less than one quarter of that in 1917. The fixed price was at the rate of $3.25 per lb. of Mo contained.

As stated in 1917 there is some prospect that properties containing large tonnages of low-grade ore may be able to continue operations in the face of decreased demand and lower prices. The great experience that has been gained particularly in England, France, and Italy, in the treatment of molybdenum ores, and in the production and use of certain alloys containing this metal, may reasonably be expected to create a steady if limited demand for this product after the war. Several plants for the production of ferromolybdenum have been erected in Great Britain, and there are others in France and Italy. It is therefore to be expected that these plants will attempt to supply as much of the European demand for ferro as possible, and that European buyers will be in the market for

[1] MINERAL INDUSTRY, 26, 455 (1917); *Eng. Min. Jour.*, Jan. 18, 1919.
[2] *Eng. Min. Jour.*, Jan. 11, 1919.

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ores and concentrates, rather than for alloys. On the other hand cheaper power and high ocean freights will make it possible for discriminating purchasers to secure their supplies of ferro and other alloys in America at lower rates than they can be produced in existing European plants.

Steel makers in general still refrain from using this metal, except in small quantities for certain purposes in which the technology is well developed. Molybdenum steels found many uses in the Allied countries during the war, and it is to be expected that sooner or later the results of careful and intensive investigations that have been made will be available for commercial purposes. The sheet steel used for making helmets is said to have contained molybdenum and the metal was also used in armor-piercing projectiles, and in certain classes of tools. In the United States it was employed in the crankshafts and connecting rods of the Liberty motors. It has also been employed experimentally in certain automobile parts and in tools.

It is stated that the Ford Motor Co., which has been interested in the development of molybdenum steels, was preparing to produce a thin armor plate, containing approximately 1 per cent. molybdenum, for use in armoring tank cars. This armor was made 1 in. thick, and while not directly specified by the Government, it would have been accepted for the reason that the steel conformed to the tests required by the regulations of the War Department.[1]

Production and Developments

Canada.[2]—The Dominion Department of Mines reports shipments from 17 different localities distributed as follows: two in Nova Scotia, four in Quebec, eight in Ontario, and three in British Columbia. There was 33,935 tons of ore treated at the concentrating plants and the total shipments of ore and concentrates amounted to 461.3 tons. The total production during 1918, representing the quantity of molybdenum sulphide (MoS_2) paid for, amounted to 378,029 pounds. The value on the basis of $1.15 per lb. of MoS_2 was $434,733. The Canadian production in 1916 was 156,461 lb. and in 1917, 288,705 pounds.

About 88 per cent. of the total Canadian production came from the province of Quebec, chiefly from the Moss mine, the property of the Dominion Molybdenite Co. at Quyon, Quebec.

There are seven mills in Canada designed for the treatment of molybdenite ores, distributed as follows:

[1] *Min. Sci. Press*, Feb. 1, 1919, p. 145.

[2] Data based on the report of the Mineral Production of Canada, 1918, Division of Mineral Resources and Statistics, Mines Branch, Ottawa. Consult also "Molybdenite Deposits of Ontario," A. L. Parsons, Ont. Bur. Mines, 1917, pp. 275–313.

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Dominion Molybdenite Co., Ltd., Quyon, Que.
St. Maurice Mines, Ltd., Indian Peninsula, Temiskaming, Que.
International Molybdenum Co., Renfrew, Ont.
Renfrew Molybdenum Mines, Ltd., Mount St. Patrick, Ont.
Steel Alloy Corp., Dacre, Ont.
Molybdenum Products Co., Haliburton, Ont.
Molybdenum Mining and Reduction Co., Alice Arm, B. C.

As will be seen by a comparison with the list given in 1917 two new mills have been built during 1918. The practice of milling commercial ores at the Mines Branch laboratories in Ottawa was discontinued in August.

Ferromolybdenum was produced, as in previous years, by the International Molybdenum Co. at Orillia, and by the Tivani Electric Steel Co. at Belleville. The Orillia Chemical Co., Orillia, Ontario, manufactures various molybdenum salts.

United States.—The production of molybdenum in 1916 was 103.37 tons of metal in 1228 tons of ore and concentrates, valued at $205,000. In 1917 the production was 175.1 tons of metal in ore and concentrates, valued at $495,350. In 1918 the production was 430.82 tons of metal contained in 2280 tons of ore and concentrates, valued at $1,257,000,[1] the largest amount yet recorded by any country.

The general situation in the United States as regards producing localities was briefly reviewed in 1917.[2] During 1918 extensive developments took place at Climax, Summit County, Colorado. The American Metal Co. has installed a mining and milling plant, and near the close of the year was reported to be treating about 250 tons of ore per day, from which was recovered 11 lb. of MoS_2 per ton of ore treated. The concentrates contained about 65 per cent. molybdenite. The Molybdenum Products Co. was operating an adjacent property, but no details with respect to their operations are available.[3]

In the Hualpai mountains, Arizona, two areas about 12 miles apart, both in Mohave County, have attracted attention. These are the Wheeler wash near the north end of the range, nearly 25 miles from Kingman, and the Deluge wash less than 30 miles from Yucca. The latter locality was the first worked for molybdenum. The Leviathan Mines Co. and the American Mineral and Chemical Co. were operating here. The ore is stated to have averaged slightly under 2 per cent. MoS_2, and a little over 2 per cent. copper. Masses of high-grade ore were found repeatedly and in one case 700 lb. of 67-per cent. ore was secured. On

[1] U. S. Geol. Surv.
[2] Mineral Industry, 26, 457 (1917).
[3] *Eng. Min. Jour.*, Jan. 11, 1919. For description of plant refer to *Bull. Am. Inst. Min. Eng.*, Oct., 1918; *Eng. Min. Jour.*, Aug. 31, 1918, p. 394; *Min. Jour.*, Sept. 14, 1918; *Chem. Met. Eng.*, Nov. 1, 1918, p. 654.

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one vein the manager of the Leviathan company estimated 16,000 tons of 2-per cent. ore ready for stoping, and at least twice this amount of probable ore. A 50-ton mill was erected.[1]

The Telluride Chief Co. was operating a property at Wheeler wash and the Arizona Molybdenite Co. was also operating in the neighborhood.

Owing to the presence of pyrites and chalcopyrite the milling problem was a serious one in this district, but it appears to have been solved.

In 1917 California prospects produced in all 243 tons of molybdenite ore, the bulk of which averaged 1.5 per cent. MoS_2, but including also some concentrates which contained 58 per cent. MoS_2. This production came chiefly from Shasta County, with smaller amounts from Inyo, Mono, and San Diego counties.[2] In 1918 prospecting operations were still in progress in a locality about 35 miles east of San Diego, and a 40-ton experimental mill had been erected.[3]

Molybdenite was found at a depth of 1320 ft. in the Silver Pick mine at Goldfield, Nev., the average content running as high as 2 per cent. MoS_2. It has not yet been determined whether it occurs in commercial quantities.[4]

The Alaska-Treadwell Mining Co. was developing a molybdenite deposit at Shakan, near the north end of Prince of Wales Island, 180 miles from Treadwell. The vein outcrops for 500 ft., and has an average width of 5 feet. A tunnel has been driven 320 ft. along the strike, showing an average width of 7.7 ft. The ore at the outcrop assays about 1 per cent. MoS_2; along the tunnel the average assay is 1.89 per cent. MoS_2. The average of surface and underground showings shows about 100,000 tons of ore which will assay about 1.58 per cent. MoS_2, of which 6270 tons with an assay average of 2.28 per cent. MoS_2 is positively blocked out. It is expected that the average yield will be 15 lb. of molybdenum per ton of ore milled. This property also promises to yield vanadium and soluble phosphorus salts as by-products. A 20-stamp mill has been installed and a 4000-ft. tramway, connecting the mine with the dock, was under construction. The company plans to erect a 2-ton Heroult furnace at Treadwell to produce ferro.[5]

There appear to be at least 10 mills in the United States erected for the purpose of concentrating molybdenum ores. The largest of these, that of the American Metal Co. at Climax, Colo., has a rated capacity of 250 tons of ore per day. The following list includes all the mills concerning which any information is available:

[1] Refer to *Min. Sci. Press*, May 19, 1917, p. 699, and Mar. 1, 1919, p. 306.
[2] California State Mining Bureau, *Bull.* 83, Aug., 1918, p. 40. For lists of producers and consumers see Preliminary Report No. 4, 1918, p. 21.
[3] H. E. Davis, *Salt Lake Min. Rev.*, June 15, 1918.
[4] *Min. Sci. Press*, Feb. 1, 1919.
[5] *Min. Sci. Press*, Jan. 11, 1919, p. 48.

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American Metal Co., Climax, Colo.
Henry E. Wood & Co., Denver, Colo.
American Mineral & Chemical Co., Copper Canyon, Ariz.
Leviathan Mines Co., Copper Canyon, Ariz.
Arizona Molybdenite Co., south of Kingman, Ariz.
Standard Minerals Co., south of Kingman, Ariz.
Arizona Rare Metals Co., Mammoth, Ariz.
Torpey Syndicate, 30 miles east of San Diego, Calif.
Mill in Shasta County, California.
Alaska-Treadwell Mining Co., Shakan, Prince of Wales Island, Alaska.

Norway.—In order to prevent molybdenite from reaching the Central Powers, the British Government made contracts for the purchase of almost the entire output of 1917, and of the first half of 1918. The price paid was very high, $4.25 per lb., and stimulated prospecting and production. Subsequently the shipping arrangement entered into between the United States and Great Britain on the one hand and Norway and Sweden on the other automatically regulated the situation, and Britain closed her contracts in June, 1918, except with the newly organized Undalen company, which held a long-time contract at a lower price.[1]

During the year a limited company was organized in Christiania for the purchase of the Knaben mines in Fjotland. The purchase price is said to have been 2,500,000 kroner. The property had belonged to the Blackwell Developing Co. since 1905. The plant is in full working order and an ore zone of considerable size has been discovered.[2]

A limited company was formed in Haugesund, Norway, with a capital of 700,000 kroner to build a ferromolybdenum plant near Sandnes. The capacity was small.[3]

Australia.—Statistical data with respect to the Australian production in recent years are not available. Small quantities of molybdenite have been produced by certain prospects in Victoria. The New South Wales production in 1916 was 54 tons, and in 1917, 70 tons, presumably concentrates.[4] Queensland production is placed at 81 tons 6¼ cwt. in 1916, 111 tons 4½ cwt. in 1917, and 110 tons 4 cwt. in 1918. The valuation placed upon this production is £34,369 in 1916, £48,618 in 1917, and £48,176 in 1918.[5] It is to be noted that the statistical year ends on June 30th, and that data with respect to the export for the calendar year are not available. Taking into account the valuation placed upon the concentrates shipped, as given above, and the fixed price which prevailed in Australia, it is evident that the tonnages here given

[1] *Min. Jour.*, Jan. 11, 1919.
[2] *Comm. Rept.*, Sept. 24, 1918.
[3] *Comm. Rept.*, Sept. 21, 1918; *Eng. Min. Jour.*, Jan. 18, 1919, p. 162.
[4] S. J. Johnstone, "Molybdenum within the Empire," *Jour. Soc. Chem. Ind.*, Dec. 16, 1918.
[5] *Queens. Govt. Min. Jour.*, Mar., 1919, p. 114.

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relate to molybdenite concentrates and not to the MoS_2 content of the ore shipped. In comparing the production of Australia with production in other parts of the world not only should the difference between the long and short tons be taken into consideration, but due allowance should also be made for the degree of concentration of the product shipped.

The Mackay Prospecting Syndicate, Melbourne, Victoria, is reported to have taken an option on a newly discovered prospect near Tenterfield in which some rich concentrations of molybdenite were found.[1]

The orebody at Maldon, Victoria, is reported to have a width of 42 ft. on the 400-ft. level, and 52 ft. on the 500-ft. level, and an average content of 35 per cent. molybdenite. The cost of mining and treatment is placed at 18s. per ton, and the weekly output capacity at 200 tons.[2]

Work carried on by the Everton Molybdenite Syndicate at Everton, Victoria, is reported to have developed an orebody containing about 10 per cent. molybdenite, and the Standard Molybdenite Mining Co. was organized late in the year to take over this prospect.[3]

The Mammoth Molybdenite Co., Yetholme, N. S. W., was operating during the year, for part of the time at least employing three shifts. The orebody is being worked on the room-and-pillar system. They are equipped with a 10-stamp battery, treating 180 tons of ore per week, producing 12½ tons of concentrates, exclusive of the concentrates recovered from the slimes, which are cleaned up once a month. Additional units were being installed for work on a larger scale. Between Nov. 5th and Dec. 3d the plant worked 440 hours, treated 677 tons of ore, and 3332 lb. of concentrates (molybdenum content not stated) was recovered.[4] The Kingsgate Molybdenite Co.'s mill ran intermittently from July 25th to August 21st, and treated 96 tons of ore, which yielded 1719 lb. of 90 per cent. molybdenite concentrates, in addition to a considerable quantity of bismuth.[5] Prospecting work was also in progress at Mount Booralong Molybdenite Mines, 28 miles north of Armidale, where it is claimed that a large orebody occurs. It is expected that the first unit of the recovery plant will be installed in February, 1919.[6]

In Queensland many small prospects are stated to have been worked intermittently during the year. Small yields are reported from the Stanthorpe Ballandean district,[7] and from the Ajax and General French leases operated by the Kitchener Blocks Molybdenite Syndicate.[8]

[1] *Iron & Coal Tr. Rev.*, Aug. 30, 1918, p. 253.
[2] *Indust. Aust. & Min. Standard*, May 23, 1918.
[3] *Indust. Aust. & Min. Standard*, Nov. 28, 1918, p. 867; Dec. 26 918, . 1041.
[4] *Indust. Aust. & Min. Standard*, Dec. 5, 1918, p. 911; Jan. 2, 1919, p. 17.
[5] *Chem. Eng. Min. Rev.*, Oct. 5, 1918, p. 13.
[6] *Indust. Aust. & Min. Standard*, July 25, 1918, p. 123; Dec. 26, 1918, 1041
[7] *Queens. Govt. Min. Jour.*, Oct. 15, 1918, p. 458.
[8] *Indust. Aust. & Min. Standard*, Jan. 16, 1919, p. 111.

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The Kitchener Molybdenum mine at Wolfram has a good showing on several levels, and is stated to have large reserves. The property is provided with a small stamp battery capable of producing about 1 ton of concentrates per week.[1]

A new discovery is reported in the Connors Range, near Cardowan, central Queensland.[2]

In West Australia, near Mount Mulgrave, and 6 or 7 miles south-southwest of Warriedar, a number of shear zones impregnated with molybdenite, scheelite, and fluorite have been found. Rich ore is stated to occur in widths which vary from 6 to 8 ft., and 10 lodes have been located and partly opened by cross-cuts.[3]

India.—The Tavoy wolfram mines produced 3024 lb. of molybdenite, valued at £626, during the year 1917.[4]

Prospects containing wolfram and molybdenite are said to have been discovered in the Yamethin district and in the adjoining Southern Shan State, in Burma, in a mountainous and roadless region 42 miles from the nearest railway.[5]

[1] *Eng. Min. Jour.*, Aug. 3, 1918, p. 238; Aug. 24, 1918, p. 371.
[2] *Queens. Govt. Min. Jour.*, July 15, 1918, p. 304.
[3] *Indust. Aust. & Min. Standard*, Jan. 16, 1919, p. 111.
[4] *Rec. Geol. Surv. of India*, **49**, Part II, p. 76 (1918).
[5] *Bull. Imp. Inst.*, **16**, No. 3, p. 307 (1918).

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MONAZITE[1]

Monazite is a mixture of the phosphates of cerium, lanthanum, thorium, didymium, yttrium, etc. It is most commonly found as a constituent of beach sands resulting from the partial decomposition of certain pegmatitic rocks. It may vary in color from pale yellow through brownish red to nearly black, and have a specific gravity of 4.7–5.2. It is valued chiefly on account of its content of thoria, which varies from mere traces up to 30 per cent.

Almost the whole of the demand for thorium is met by monazite sand, but occasionally small parcels of other thorium minerals come into the market. Amongst these may be mentioned thorianite and thorite.

Thorianite was discovered in Ceylon in 1904 in the refuse from gem washings near Belangoda, and was first supposed to be pitchblende. An examination made at the Imperial Institute showed that it contained a very large quantity of thoria, and was a new mineral. Thorianite, which contains from 60 to 80 per cent. thoria and up to 30 per cent. uranium oxide, occurs in small black cubes of sp. gr. about 9.3. In 1905, about 9 tons of the mineral was produced in Ceylon and sold at prices up to £1700 per ton. An active search for further deposits has since been carried out by the officers of the Ceylon Mineral Survey, which is being conducted under the auspices of the Imperial Institute, but, so far, no large deposits have been located. Isolated specimens of the mineral have been found in Madagascar, Russia and Japan.

Thorite is a silicate of thorium containing about 65 per cent. of thoria. It occurs in and has been exported from Norway and Ceylon, but owing to the small quantity available, it is not an important thorium mineral.

Deposits of monazite sand have been worked on the coast of Brazil, in the States of Bahia, Espirito Santo and Rio de Janeiro, in North and South Carolina, U. S. A., and in Travancore, India.

Until the rare-earth gas-mantle was invented, there was practically no demand for the mineral monazite, the small quantity required being obtained at a high price from certain deposits in Norway and Sweden. In 1893, when the incandescent mantle became a commercial success, the demand for thorium exceeded the supply.

Brazil.—The monazite occurrences may be roughly divided into three groups: (1) Deposits lying along the shore (Marinhas) claimed by

[1] Largely abstracted from an article by Sydney J. Johnstone, *Jour. Soc. Chem. Ind.*, Oct., 1918, with additions as indicated in the footnotes.

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the Federal Government. (2) Deposits on private land situated immediately behind the Marinhas. (3) Inland deposits.

The greater proportion of the monazite exported from Brazil during recent years has been obtained from the first variety of deposits situated in the States of Espirito Santo and Bahia. When first exported the crude sand was sufficiently valuable to permit of direct shipment, but, in later years, owing to a falling off in grade, preliminary concentration has been rendered necessary. The working of the second type of deposit has presented several difficulties, amongst which may be mentioned the uncertainty in fixing the extent of the Marinhas, which extend 35 yards inland from mean high-water mark. The inland deposits are in the interior of Brazil, and only those occurring in small streams and bottom lands are of commercial importance. The content of monazite in the gravels of these streams, etc., averages about 0.3 per cent. (about the same quantity as is found in the Carolinas). The working of the inland deposits is expensive, owing to the high cost of transport to a port of shipment. The Brazilian deposits were vigorously worked by the German syndicate up to 1910, when another potential producer came into the market.

The following table shows the destination and quantity of the monazite sand concentrates exported from Brazil during recent years so far as figures are available:

Destination.	1911, Tons.	1912, Tons.	1913, Tons.	1914, Tons.	1915, Tons.	1916, Tons.
Germany	1,860	1,823	251	.....	.....	.....
France	1,078	928	766	.....	.....	.....
United States	689	590	394	590	.....	.....
Great Britain	.....	1	3	.....	426	364

India.—In 1909, the representative of an English registered mining company had discovered rich deposits of monazite on the seacoast of Travancore, Southern India, which were found to contain monazite nearly twice as rich in thoria as the pure Brazilian mineral. A concession was obtained in Travancore, and it is stated that attempts were made in the United Kingdom to obtain the additional capital required for working the deposits, but without success. Recourse was therefore made to foreign financiers, and a certain German company supplied the required capital, but did not appear in the transaction. The whole of the output of monazite was sold to Germany, and this continued up to the outbreak of war. This arrangement was highly profitable to all concerned, as the royalties and production costs of the Travancore sand were considerably lower than those of the Brazilian material containing only half the amount of thoria.

An official investigation was made shortly after the outbreak of war

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with the result that enemy interests in the company were eliminated, German contracts canceled, and the company so reconstituted that in future the control must remain in the hands of British-born subjects. An important clause in the undertaking accepted by the shareholders stipulates that the company must be ready at any time to sell monazite at a fair price to British firms who wish to purchase the material for the purpose of manufacture.

The Travancore deposits as worked from 1910 to 1914 occur on the seashore, chiefly to the north of Quilon, monazite having been found over a total area of 1427 acres. A rough calculation by Mr. I. C. Chacko places the probable amount of monazite available at about 1,776,000 tons. This is based on the assumption that the crude sand contains 10 per cent. of monazite and exists to an average depth of 2 ft., although in many places the depth is nearer 20 ft. During 1916–17 a large proportion of the Travancore output was sold to the United States.

Monazite sand has been found in several other localities in India, but not in commercial quantities.

Ceylon.—During the past 10 years, a considerable amount of work has been carried out under the auspices of the Imperial Institute on the occurrence and distribution of thorium minerals in Ceylon. As a result monazite has been found in many localities and a beach deposit is about to be worked, concentrating machinery having been exported from the United Kingdom. As a general rule, Ceylon monazite, when pure, contains about 10 per cent. of thoria, but occasionally samples carrying as much as 30 per cent. are found.

Monazite is known to occur in many parts of the British Empire, but the only deposits at present worked are those of Travancore and Ceylon.

Africa.—Numerous analyses of monazite from Nyasaland and Nigeria have been made at the Imperial Institute. The percentages of thoria found in the pure monazites from these localities were: Nigeria, 2.3–8.0; Nyasaland, 7.1.

Union of South Africa.—The mineral has been reported to occur in several localities, but the content of thoria present is usually below 3 per cent., thus making the mineral unsalable. At a mine about 60 miles northeast of Pretoria, much monazite carrying 3.5 to 4.5 per cent. of thoria is said to occur in the dumps. Monazite carrying 6.5 to 7.0 per cent. of thoria has been discovered in alluvial tin deposits at Embabaan, in Swaziland.

Treatment of the Crude Sand before Export.—The crude sand may contain from 0.2 to 60 per cent. of monazite, but the material to be salable in Europe must contain at least 4 per cent. of thoria. It is evident,

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therefore, that the Brazilian material must be concentrated so as to contain at least 70 per cent. of pure monazite. As a matter of fact, it has become customary to dress both the Brazilian and Travancore sand to a purity of 85 or 90 per cent. Most of the minerals which occur in the sand with monazite, *e.g.*, quartz, garnet, rutile, magnetite, ilmenite, zircon, etc., have a much lower specific gravity, and so a preliminary concentration can be effected by sluicing. The final separation of the monazite from minerals of nearly the same specific gravity is usually effected by means of either an electromagnetic separator or air concentration.

The world's production of monazite sand concentrates during recent years is shown in the following table:

WORLD'S PRODUCTION OF MONAZITE SAND

	Brasil. Quantity, Tons.	United States. Quantity, Tons.	Travancore.[1] Quantity, Tons.
1909	6,359	242.0	*Nil.*
1910	5,345	44.3	*Nil.*
1911	3,627	1.6	819
1912	3,344	0.6	1,135
1913	1,415	*Nil.*	1,234
1914	590	*Nil.*	1,185
1915	433	16.1	1,108
1916	*Nil.*	16.5	1,292
1917	1,118	34.7	597

[1] Exports.

Thus in 1915 India produced 73 per cent. of the world's output of monazite and 90 per cent. of the total thorium production.

The Thorium Nitrate Market.—Shortly before the outbreak of war the position of the British makers of incandescent mantles became serious in regard to their future supplies of thorium nitrate. The German makers of the salt by virtue of their association with the syndicate of monazite producers had control of the entire output of monazite from the Travancore deposits and of a very large proportion of the Brazilian mineral. Thus it became possible for them to decree how much thorium nitrate the British incandescent-mantle manufacturers were to be allowed per annum, the supply being granted on condition that they undertook to purchase solely from the syndicate for a period of years. This condition of affairs would probably have prevented any expansion of the British incandescent-mantle industry except by German permission, and would have discouraged any British chemical manufacturers from attempting to make thorium nitrate on a large scale, as the free market would be very restricted. The majority of incandescent-mantle makers had to agree to this arrangement, but a small number were able to make contracts with certain French firms who had obtained control of the output of a portion of the Brazilian deposits. At that time, practically no thorium nitrate was being made in the United Kingdom from monazite sand, the only production being from waste mantle ash. The quantity of

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thorium nitrate obtained from this source probably amounted to about one-fifth of the country's requirements. The outbreak of war upset the German control, and as supplies from Germany ceased the trade found it difficult to get sufficient material to use. The price of thorium nitrate rose from about 19s. per kilo to nearly 90s. late in 1914. The situation was eased somewhat by imports from France, and later fairly large amounts were obtained from the United States. The supplies, however, were quite inadequate to meet the demand, and the price remained at about three times the pre-war figure. The shortage of thorium nitrate in 1915 caused several of the more important incandescent-mantle manufacturers in the United Kingdom to consider the question of producing thorium nitrate for their own requirements, and it is pleasing to record that several have been successful in this respect.

Mesothorium.[1]—An excellent substitute for radium for certain purposes is mesothorium. This is a radio-active element found in monazite sand and other thorium minerals. When first extracted it is not in a satisfactory condition for luminous paint, but must be allowed to "ripen" for several months or even a year before it can be used. During this time the alpha radiation which is required for luminous paint becomes sufficiently strong. On the other hand the beta and gamma radiation of mesothorium grows rapidly and it can be used for medical purposes within a few days after preparation.

Radium has a long life, half of it decaying in approximately 1600 years. Mesothorium on the other hand has a short life, 5 or 6 years being its useful life for luminous-paint purposes. The price in the past has varied from 40 to 60 per cent. of that of radium, the comparison being on products of equal activity. For medical purposes, therefore, it cannot compete with radium as long as there is plenty of the latter; for luminous paint, to be used on objects which themselves have a short life, it is an excellent substitute for radium and will tend toward the saving of radium for medical purposes.

Shortly after the United States entered the war the Bureau of Mines made a coöperative agreement with the Welsbach Co. of Gloucester, N. J., for the study of methods of extraction and recovery of mesothorium, which is now one of the regular products made by this company. The next largest producer of thorium salts in the country, about the same time became interested in the recovery of mesothorium and worked out its own methods. Consequently at the present time mesothorium is recovered from practically all the monazite sand treated in the United States.

Cerium Earths.—As already mentioned, thoria constitutes, at the

[1] *Salt Lake Min. Rev.*, Dec. 30, 1918.

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most, only about 9 per cent. of the monazite sand of commerce, the remaining 91 per cent. being made up of ceria and its allied rare earths and phosphoric acid. These cerium earths, which constitute about 60 per cent. of the same, were for many years a drug on the market, and enormous quantities accumulated at the chemical works where thorium nitrate was made. The only steady consumption for cerium compounds was for use with thorium nitrate in incandescent mantles, but as the mantle contains only 1 per cent. of cerium oxide to 99 per cent. of thorium oxide, this demand was small. For many years chemists searched for a profitable means of utilizing this waste, and many uses were suggested, such as for coloring glass yellow, as a mordant in leather dyeing, cure for sea-sickness, electric lamp filament, and coloring porcelain. It was not until 1903 that a use was found which called for any considerable quantity of these waste oxides. In that year, Welsbach discovered that if these oxides were reduced to the metallic state the resultant metal, when filed, gave off a bright shower of sparks sufficient to ignite an inflammable gas. The sparking properties, however, were not permanent, being confined to the surface layer of the metal.

Welsbach disposed of his original patent for making the alloy for £30,000 to a company which monopolized the market for a number of years, but later the patent was disputed and its operation was limited.

Subsequently, it was found that better results were obtained when the mixture of metals was alloyed with about 35 per cent. of iron. This product, known as ferrocerium or cerium pyrophoric alloy, constituted the sparking substance in the majority of automatic cigar lighters sold before the war.

Ferrocerium was made in small quantity in England by a company of German association from material imported from Germany, and was sold in June, 1914, at about 15s. per lb. Prior to the outbreak of war it was made almost entirely in Germany and Austria, where its selling price fell to 8s. 6d. per lb. At the present time, a fairly large amount is being produced in the United States, but the price has now reverted to somewhere about the original figure of £5 16s. per lb.

Pyrophoric Alloy.[1]—No data are available as to the total production in the United States of cerium, or cerium mixed metal, as it is known to the trade, during 1918. The production of this alloy probably runs into 1000 to 2000 lb. per month. Prior to 1917, the alloy was manufactured under Austrian patents, but, following the seizure of these patent rights by the Alien Property Custodian, licenses were granted to several American manufacturers to produce the metal, and, as a result, the greatly inflated price took a severe drop. During 1916 the price was

[1] H. C. Meyer, *Eng. Min. Jour.*, Jan. 11, 1919.

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$25 per lb., but in the late spring of 1917 the market dropped to $18 or $20 for moderate-sized lots, with slightly lowered figures for large quantities, under contract. Ferrocerium is an alloy consisting of, approximately, 30 per cent. iron and 70 per cent. cerium, with lanthanum, didymium, and other ingredients.

Monazite Supply in the United States

The following tables show the amounts of thorium-bearing materials imported into the United States during the past several years.

IMPORTS OF THORIUM NITRATE, THORIUM OXIDE AND MONAZITE (a)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption	1910	108,597	$218,713	$2.01
	1911	121,111	238,841	1.97
	1912	117,485	225,386	1.92
	1913	112,105	212,263	1.89
	1914	101,927	239,376	2.35
	1915	67,406	169,617	2.52
	1916	909	3,884	4.27
	1917	1,188	2,359	1.98
	1918	*Nil.*	.....	.....
Thorium oxide and other salts entered for consumption	1915	139	349	$2.51
	1916	4,099	9,487	2.36
	1917	11	293	26.64
	1918	28	124	4.43
Monazite sand (and thorite) entered for consumption	1911	705,149	$60,542	$0.086
	1912	556,959	47,334	0.085
	1913	1,145,010	94,425	0.082
	1914	770,842	61,595	0.080
	1915	1,873,971	161,456	0.117
	1916	1,221,399	120,077	0.098
	1917	4,598,926	297,898	0.065
	1918	2,994,515	204,661	0.068

(a) Bureau of Statistics of the Department of Commerce.

MONAZITE PRODUCTION IN THE UNITED STATES

Year.	United States. (a)			North Carolina.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1906	846,175	$152,312	$0.180	697,275	$125,510	0.180
1907	547,948	65,754	0.120	(c)456,863	54,824	0.120
1908	422,646	50,718	0.120	(c)310,196	37,224	0.120
1909	541,931	65,032	0.120	(c)391,068	46,928	0.120
1910	99,301	12,006	0.121	(b) 83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.120	*Nil.*	.....	.....
1913	*Nil.*	.....	.....	*Nil.*	.....	.....
1914	*Nil.*	.....	.....	*Nil.*	.....	.....
1915	36,000	3,600	0.100	(d)	.....	.....
1916	37,872	3,400	0.090	37,872	3,400	0.090
1917	(d)	.....	.....	77,743	3,806	0.049
1918	*Nil.*	.....	.....	*Nil.*	.....	.....

(a) Statistics are those of the U. S. Geological Survey. (b) Statistics for 1910 furnished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey. (d) As there was only one producer in 1915 and 1917, statistics can not be given.

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The Brazilian sand carries an average of 6 per cent. thorium oxide, and is preferred by certain manufacturers of thorium nitrate to the Indian sand, which carries an average of 8 per cent. thorium oxide. Prior to 1914 the Indian deposits as well as those of Brazil were practically controlled by German interests, and nearly all the thorium nitrate was manufactured in Germany and Austria. Under the control of the German syndicate the price of the nitrate was so regulated that French, English, and American independent manufacturers were practically driven out of business. The German syndicate had large mantle factories in all of the above-named countries, which served further to strengthen its strangle hold on the market. The war, however, put an end to all these conditions, and several independent manufacturers are now supplying consumers with thorium nitrate equal in quality to the best Austrian or German nitrate. There was little or no fluctuation in price in 1918. During the first half, the price ranged from $6 to $6.50 per lb., with lower prices for yearly contracts. Toward the end of the year, owing to keen bidding among nitrate manufacturers for the 1919 requirements of the mantle trade, the price dropped to $5 and $5.25 per lb., according to quantity.

IMPORTS OF MONAZITE SAND AND THORITE
(Fiscal years ending June 30) in Pounds

From	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Brazil	1,115,429	1,104,984	1,102,300	1,464,963	352,780	1,079,427	1,122,998
England	.....	.....	.....	291,342	1,170,721	1,134,433	1,341,571
Canada	.....	.....	.....	2,500	.....	2,340	1,786,050
British India	.....	.....	.....	.....	.....	.....	725,356
Total	1,115,429	1,104,984	1,102,300	1,758,850	1,523,501	2,216,200	4,975,975

The above table shows the source of monazite imported into the United States. Brazil has for a number of years furnished a fairly constant amount, and recently British India is furnishing increasing amounts. As neither Canada nor England are producers of monazite, the amounts credited to them are indirect shipments, probably mostly from British India.

H. C. Meyer, *Eng. & Min. Jour.*, Jan. 11, 1919.

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NICKEL

By Thos. W. Gibson

Uses.—Nickel is a modern metal, its predominant uses having been developed within the last 30 years. Previously, nickel was principally employed in making white malleable alloys of nickel and copper, and of nickel, copper and zinc, the former being known as cupro-nickel, and the latter as German silver, packfong, argentite, etc. Cupro-nickel was largely rolled into sheets, while German silver, or, as it is now known, nickel silver, formed the bodies of tableware for plating with silver. The introduction of electroplating considerably enlarged the use of nickel, and the metal was and is employed by various countries, either alone or alloyed with copper, for coins of small denomination. The total quantity of nickel consumed say 50 years ago amounted to a few hundred tons per annum, rising in 1889 to 2500 or 3000 tons at most.

In 1889 James Riley of Glasgow published the results of a series of experiments made in alloying steel with varying proportions of nickel. It was at once recognized that the remarkable increase in tensile strength, elastic limit, and non-corrodibility which a small percentage of nickel conferred on steel had placed practically a new material in the hands of structural engineers. In the decade beginning 1890, many scientists and experimenters in Britain, on the continent of Europe, and in the United States, investigated the properties of nickel steel. For ordinary commercial purposes, the best effects were obtained from steel containing 3 or 3.5 per cent. up to 5 per cent. of nickel. Armor-plate for war vessels was one of the first uses in which nickel steel showed its superiority, particularly when reinforced by special surface treatment.

The useful nickel steels range from 2 to nearly 50 per cent. of nickel. The introduction into the alloys of other substances, such as chromium, manganese, etc., modify the character and vary the uses for which the steel is suited. Nickel steel has been used in the construction of numerous large and important bridges and other structures for railway, canal and passenger traffic, for locomotive forgings, electric railway gears, marine-engine works, stationary-engine construction, automobile parts, mill machinery, wire cables, axles and railway rails for tunnels or curves; in fact, wherever toughness and strength, as well as a minimum of weight, are desirable. For naval and military purposes nickel is almost indispensable, for besides being used as an ingredient in armor-plate, it enters

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into the manufacture of ordnance, projectiles, protective deck-plate, gun-shields, cartridges, and many other articles of war equipment.

Nickel also forms many alloys for electrical use as resistance materials, such as nickel-chromium and nickel-manganese. As pure metal or as rolled coating over iron, nickel is manufactured into kitchen utensils, as nickel sulphate it is used for hydrogenizing oil into fats, and as nickel oxide for coloring or decolorizing purposes in the manufacture of glass. In the metallic form, nickel is made into watch and cigarette cases, and like objects. It is drawn into wire, used for spark plugs, and electrical leading-in wires. Monel metal, a product of the International Nickel Co., and containing approximately 67 per cent. nickel, 28 per cent. copper, and 5 per cent. manganese and iron, possesses great incorrodibility and high tensile strength. It is used for propeller blades, valves, castings for oil stills, permanent roofing, tie-rods, bolts and nuts, enameling and burning points, shafting and pump-rods, etc.

Ores.—Nickel is widely disseminated, being found in many igneous rocks, and also in certain iron ores. It is believed that the total amount of nickel existing in the earth's crust is greater, for example, than of copper. Workable deposits are, however, few. Indeed, they may be said to be rare, production being confined at present very largely to two sources, Sudbury District in the Province of Ontario, Canada, and the French island of New Caledonia.

Nickel ores are of three kinds: (1) Arsenical, (2) silicates or oxides, and (3) sulphides.

Arsenical ores were the first to be worked, and for a time formed the sole source of the metal. Such ores are found in Saxony, Bohemia, France, and more lately, chiefly as niccolite, in association with the silver ores of Cobalt, Ontario, which now produce more nickel than any other arsenical source.

Silicates or oxidized ores occur more abundantly than arsenical. The well-known mines of New Caledonia, which for several decades yielded the bulk of the world's nickel, are of this class. Similar deposits occur in Madagascar, Greece, and the island of Seboekoe near Borneo, where the ore carries about 1 per cent. nickel and 2.21 per cent. chromium. In Cuba at Mayari, Moa and Cubitas, very large surface bodies of iron ore are found containing from 0.5 up to 1 per cent. nickel, and 1 to 2 per cent. chromium. A. C. Spencer estimates that the combined area of these deposits is 56,000 acres, and that they contain 1500 million tons of ore. If the average nickel content is even 0.5 per cent., it will be seen that in the aggregate these ores contain an enormous quantity of nickel.

The nickel deposits of New Caledonia, Madagascar, Seboekoe and Cuba have, broadly speaking, a common origin. They are derived from

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the weathering of basic rock, say peridotite or serpentine, and rest practically on the surface of the rock from which they have been derived. If the parent rock contained nickel or chromium, these elements are found in the residual mass. Such lateritic ores may also carry cobalt or manganese. They are found for the most part in tropical regions, or at any rate regions where the rocks have remained unaffected by glaciation.

The third class of ores, namely the sulphides, consist essentially of pyrrhotite and chalcopyrite occurring together. The ores of Norway are of this type; so also are those of Tasmania and South Africa. The extensive deposits of the Sudbury region are made up of pyrrhotite and chalcopyrite, the nickel mineral itself being pentlandite, a sulphide of nickel.

Canadian Deposits[1]

The last-named deposits were discovered in 1883, during the building of the Canadian Pacific railway, and were first regarded as containing copper ore only. Difficulties in smelting led to the discovery that they carried nickel, and these mines now form by far the largest source of the world's production of nickel, probably 80 per cent. or more of the whole.

During the great war the naval and military requirements of the Allies called for immense quantities of nickel; under this stimulus the Sudbury mines were worked at maximum capacity, and the output rose to a record point. The two principal companies are the International Nickel Co. and the Mond Nickel Co. The mines of the former include Copper Cliff, Creighton, Crean Hill, Frood, Vermilion, No. 2 and others. The Creighton mine is probably the richest nickel deposit in the world. Its ore contains an average of 4.44 per cent. nickel and 1.56 per cent. copper, and during war-time 4000 tons were raised daily from the shaft. Diamond-drilling explorations have shown it to contain very large reserves of ore. Crean Hill contains more copper than nickel. The Frood is probably the largest deposit of nickel ore in the Sudbury region, but it is of lower grade than the Creighton.

The International Nickel Co.'s works are thoroughly modern and very extensive. The product is a high-grade matte, containing about 55 per cent. nickel and 25 per cent. copper. Most of the matte refining is done at Bayonne, N. J., by what is known as the Orford process. This consists of smelting the matte with salt cake, the tops and bottoms thus produced being repeatedly smelted until the separation is complete. In 1918 the company completed a new refinery at Port Colborne, Ont., which also operates the Orford process, and has an initial capacity for

[1] The whole subject of Nickel was fully investigated, with special reference to the Canadian deposits, by the Royal Ontario Nickel Commission, whose Report, published in 1917, may be had on application to the Secretary of the Commission, Toronto, Ontario.

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refining 7500 tons of nickel yearly, and 4000 tons of copper. Nickel actually refined last year amounted to 1725 tons. The company also completed additions to their smelter at Copper Cliff, Ont., and commenced a new dam on the Spanish River, which will furnish considerable additional hydro-electric power. The Annual Report for the year ending Mar. 31, 1919, states that the total income was $11,186,304 and profits $5,922,629, comparing with the income of $16,181,500 and profits of $10,129,987 for the preceding fiscal year. During the past year the company operated at full capacity until the signing of the armistice, when production was cut to about one-third.

The Mond Nickel Co. is an English concern whose new smelting works are at Coniston, east of Sudbury. Its principal mines are: Levack, Garson, Kirkwood, Victoria and Worthington. This company also purchases the ore produced by the Alexo mine, a small deposit in the Porcupine area, quite outside the Sudbury mineral belt. The ore is similar to that of Sudbury, but contains more nickel and less copper. The Mond company refines its matte by the highly ingenious process perfected by Dr. Mond, the founder of the company, the works being at Clydach, Wales. The process utilizes the affinity of carbon monoxide for finely divided nickel. The copper is recovered as sulphate, for which there is a large demand in the vine-growing countries of Europe, where it is used to combat the fungus enemies of the grape.

More recently, the British America Nickel Corporation has entered the Sudbury field, having acquired the Murray, Whistle, Elsie and other mines. This company was assisted by the British Government, which took over its bonds to the extent of $3,000,000 and has a controlling interest in the stock, thus securing a source of nickel supply independent of private companies. Exploration with the diamond drill has shown that the Murray mine contains a very large body of ore of medium quality. The Whistle mine is situated on the north range and has not been fully developed. The company's smelter at the Murray mine is nearing completion, and its refinery is being built on the banks of the Ottawa river near Hull, in the Province of Quebec. The British America company will use the Hybinette electrolytic process of refining. The advantages claimed are that it produces no noxious effluents, and that it enables the precious-metal constituents of the matte to be entirely recovered.

Besides gold and silver, the Sudbury ores carry small proportions of the platinum group of metals. These can be saved by the Mond and electrolytic methods of refining, but in the operation of the Orford process and the production of Monel metal they are largely lost. It has been demonstrated that the platinum group of metals is more abundantly

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contained in ore deposits of the rocky type, such as the Victoria, Worthington and Vermilion. These mines now yield a comparatively small proportion of the ore, and the outlook is that the platinum, palladium and iridium metals will have a smaller production in the future than in the past. The Royal Ontario Nickel Commission estimated the reserves of proven, probable and possible ore in the Sudbury field as 150 million tons. Since the date of their report, diamond drilling has added considerably to these figures.

On the cessation of the war the demand for nickel greatly lessened, and the International company has closed the Crean Hill mine and considerably reduced its working force at the Creighton. The Mond company has also reduced its operations. It is understood that large stocks of metallic nickel remain in the hands of several of the Allied governments, including Great Britain, France and the United States, and until these stocks are absorbed or greatly reduced by the requirements of peaceful industries, nickel mining in Ontario will be less active.

Origin of Sudbury Ores.—The nickel-copper deposits of the Sudbury area are closely associated with a great pre-Cambrian intrusion of norite, which is sometimes spoken of as the "nickel eruptive." The latter completely surrounds an oval-shaped series of sedimentary rocks of Animikie age. This belt of norite surrounding the sedimentary rocks has a width of 1 to 4 miles. The length of the belt of norite and enclosed sediments is about 36 miles, while the maximum width is about 13 miles.

Most of the ore deposits occur along the outer basic edge of the norite, while a few occur in dikes which run from the main norite mass. The norite intrusion has partly the form of a sill and partly the form of a great dike. The ore consists of sulphides, mainly pyrrhotite, chalcopyrite and pentlandite, the latter constituting the nickel ore and containing about 22 per cent. nickel.

The origin of the orebodies, like the origin of many other ore deposits, has been the subject of much controversy. It may be said, however, that all those who have studied these occurrences agree that the sulphides of nickel and copper have been derived from the norite. The manner in which the sulphides became concentrated and made their way to the outer basic edge of the norite is the point on which there is disagreement. Some observers believe that the sulphides settled to the bottom of the molten norite where the norite occurs in the form of a sill. Of course in those cases in which the norite has a dike-like form, with vertical contacts, this explanation does not satisfactorily explain the origin of the ore. The process by which the ore is believed to have settled to the bottom of the molten norite before cooling was complete is known as magmatic segregation. There are others who be-

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lieve that the ores were deposited from hot, mineral-laden, magmatic solutions which were given off by the norite as it cooled. The ores were deposited from these solutions along the basic edge of the norite in crushed and disturbed zones. The process by which these magmatic waters reached the edge of the norite is not understood.

There is a third theory in regard to the origin of the ores. This theory suggests that the deposits were formed by the intrusion, after the norite solidified, of masses of molten sulphides, these masses now constituting the orebodies.

New Sources of Nickel

East Indies.—Very large deposits of iron ore of the lateritic type have been found in the central part of the Island of Celebes, a Dutch possession near Borneo, which essentially resemble those of Seboekoe, a neighboring island already mentioned. The Mining Department of the Dutch East India Government has recently issued a report descriptive of these deposits, which are estimated to contain at least 1000 million tons of ore. In the Verbeek Mountains deposits occur also derived from the peridotite and serpentine rocks, containing nickel as well as iron. These ores are similar in character to those of New Caledonia. Assays run up as high as 10 and even 25 per cent. of nickel, but in general the nickel content of the unselected ore is considerably lower. Two experimental pits in a deposit at Soroako gave throughout a depth of 9 and 12 meters respectively an average content of 2.31 and 2.50 per cent. nickel. On Nenejangan hill, eleven pits were dug, and the average content of the ore was estimated at 2.5 to 3 per cent. nickel. On Boetoh hill nearby, the average content from twenty-one pits and trenches was estimated to be over 5 per cent. In general, the limited amount of exploration done has been restricted to the ridges and individual deposits; the latter, though probably numerous, do not seem to be extensive. At Boetoh, the total quantity of nickel ore was estimated at 50,000 to 60,000 tons, but the report adds "to win this quantity of ore, more than 1,000,000 cubic meters of material would have to be handled."

United States.—At Fredericktown, Mo., the Missouri Cobalt Co. is working a deposit of ore containing 2 to 2.5 per cent. copper; 0.5 to 0.8 per cent. nickel; 0.5 per cent. cobalt, and 0.5 oz. of silver per ton. The ore is in a fairly flat-bedded deposit at the contact of sandstone and limestone, and is worked at a depth varying from 2 to 8 feet. All the metals are present as sulphides, and are associated with considerable pyrites. The company has put up a 300-ton mill in which the ore is concentrated, four or five parts into one, by gravity concentration aided by flotation. From 85 to 95 per cent. of the metals is recovered in the

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concentrates. Part of the lead is separated in the mill and shipped directly to lead smelters. The concentrates are roasted and smelted in a blast furnace, and the matte so obtained is leached after roasting, the residue being converted into anodes. The copper is recovered by electrolytic refining, and the cobalt and nickel by chemical precipitation. The cobalt and nickel refineries began operation about the beginning of 1919. The nickel from these works is the first produced in the United States from native ore for a number of years.

West Indies.—At Sierra Prieta, 19 miles northwest of Santo Domingo, in the island of that name, a low-grade nickel deposit called the Perseverancia mine has been located, and the Perseverance Nickel Co., composed of Cuban capitalists, has been formed to operate it. A considerable amount of preliminary work was done in 1918, principally in building houses and making roads.

South Africa.—The occurrence of nickel at Insizwa, on the boundary between East Griqualand and Pondoland, South Africa, has been described by A. L. du Toit, and also by W. H. Goodchild. The ore is of the sulphide type, but so far, no extensive development has been done, and no bodies of consequence located.

At Vlakfontein, No. 902, in the Rustenburg district of the Transvaal, printed accounts describe a huge laccolith of red granite as surrounded by a marginal fringe of norite and basic rocks, thus apparently approximating the geological conditions characteristic of the Sudbury district. The norites are usually about 6 miles in width, but spread out to a maximum of 70 miles. On or near this marginal zone, gossan outcrops show remains of ancient workings, evidently for copper. Where shafts have been sunk on these outcrops, the general experience has been that down to 40 ft. the gossan is ill-defined, and carries nothing but traces of copper with occasional blocks of unaltered sulphide ore. From this depth nickel appears in conjunction with the copper as an irregular impregnation, becoming richer in metallic contents at 100 ft., the maximum depth yet reached. Assays of the ore at various openings and depths show 0.57 per cent. to 3.25 per cent. nickel, and 0.25 to 6 per cent. copper. As yet no important ore masses have been found, but the amount of development work done is not large.

Canada.—In Ontario, nickel-copper ores have been found, though not as yet in quantity, in the township of Strathy. The association is with the serpentine and the ore is of the sulphide or Sudbury type. The find, taken in conjunction with the deposit at the Alexo, is significant as showing that nickel ore exists outside of the Sudbury area and under quite different geological conditions. Nickel ore has also been reported from the township of Munro, east of the Temiskaming and Northern

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Ontario railway, and from the neighborhood of Lake Shebandowan, Thunder Bay district.

The large bodies of nickel-copper ore located in 1916 and 1917 by the E. J. Longyear Co., in the township of Falconbridge, Sudbury district, have not yet been opened. The discoveries are notable as having been made through a covering of drift 50 to 250 ft. thick, entirely by the diamond drill. The norite contact was nowhere visible, and was located by a series of shallow "scout" holes sunk on each side of its supposed position.

Germany.—The Deutsch-Böhmischa Nickel Gruben Co. has been formed at Berlin, with a capital of 1,200,000 marks, to exploit nickel-ore deposits near Schluckenau on the German-Bohemian frontier.

Technology

Nickel-copper Steel.—The manufacture of nickel-copper steel direct from Sudbury ore has been begun by Electric Steel and Engineering, Ltd., at Welland, Ont. Experiments have shown that in nickel steel a portion of the nickel may be replaced by copper without detriment to the quality of the steel. Experimental bars and sheets have been made, which have proven satisfactory, and even gun tubes, which are being tested by the British Government. It is said that slag from the blast furnaces which produce low-grade matte can be used for making such steel, as it invariably retains small percentages of nickel and copper. If the attempts prove successful, the waste of say one-half million tons annually of iron in the pyrrhotite ore, which now goes into the slag, will be saved. On the other hand, the precious-metal contents will be lost.

Electrolytic Refining.—George A. Guess, Professor of Metallurgy in the University of Toronto, has invented a process for the electrolytic refining of nickel. The process is based on the fact that if an anode of crude nickel, which may contain copper and iron, is electrolyzed in a bath of nickel sulphate in which is suspended finely divided calcium carbonate, there is deposited on the cathode, which is suspended in a sack diaphragm, metallic nickel practically free from copper and iron. The action of the finely pulverized limestone appears to be represented by the following equation:

$$2CuSO_4 + 2NiSO_4 + 3CaCO_3 = 2CuO.{}_2NiO.SO_3 + 3CaSO_4 + 3CO_2$$

The copper is precipitated as a double basic sulphate of copper and nickel, which is quite insoluble. The function of the diaphragm is to protect the cathode from mechanical pollution by contact with the insoluble copper salt. Since an equivalent amount of nickel is combined with the copper in the insoluble basic sulphate, it is obvious that the copper content of the anodes should be as low as possible. Preliminary treatment of the con-

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verter matte to remove copper is necessary. Two methods at once suggest themselves for doing this. The first is by leaching the roasted matte with dilute sulphuric acid, as is done in the preliminary operation for the Mond process. The second method would be a fusion with coke and salt cake (Na_2SO_4), which is the preliminary step in the Orford process. The Guess method has been successfully employed on a small scale and arrangements are pending for a more extended trial. The advantages claimed are (1) time is saved, (2) the cost of refining is reduced, (3) the gold, platinum metals, etc., can be recovered.

Nickel in Steel.—The increased use of nickel steel for the manufacture of war munitions has naturally led to a close study of its structural and other qualities. Papers read at the February 1919 meeting of the American Institute of Mining and Metallurgical Engineers, one by C. Y. Clayton, F. B. Foley and F. B. Laney, and one by Henry S. Rawdon, dealt with the so-called "flakes" sometimes seen in steels of this kind. It was stated by the last-named that "flakes do not appear to be found in the plain carbon steels; they have been found, however, in abundance in some of the simple alloy steels that are being used in such vast quantities; that is, nickel steel of the approximate composition 0.40 per cent. carbon and 3.50 per cent. nickel, and in the chrome-nickel type." These flakes or spots are described by Messrs. Clayton, Foley and Laney as flaky fractures in which occur bright, silvery spots or areas. They vary in longest diameter from 1.5 to 12.7 mm., and are surrounded by the usual gray to smoke-colored metal which may be woody, silky or the usual granular, the silvery spots being the flakes. From microscopic examination, the flakes appear to be made up of more coarsely granular material than the surrounding metal, and in many instances what appear to be the boundaries of polyhedral grains are distinctly visible. The most characteristic effects of flakes, say the authors, are the loss of ductility and corresponding decrease in reduction of area; tensile strength and elastic limit are also reduced, but not so markedly as the other properties. In shop-practice it was often found necessary to make four gun forgings in order to get one good jacket. It was also stated in discussion that the presence of more than 0.05 per cent. of nickel or chromium interfered with the lap-welding of steel, for instance in the making of pipe by this method.

Statistics

The following tables give imports into and exports of nickel from the United States, and also figures of production in Canada and exports from that country. Much the larger part of the nickel refined or used in the United States comes from Canadian mines.

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Year.	Imports.						Exports.	
	Nickel Ore and Matte.			Nickel Alloys. (a)		Nickel Mnfrs.	Nickel. (b)	
	Long Tons.	Nickel Content, lb.	Value.	Pounds.	Value.	Value.	Pounds.	Value.
1904.	8,548	(c)	$915,470	589,555	$203,071	$2,950	7,519,206	$2,130,933
1905.	13,451	(c)	1,626,920	941,966	331,920	3,291	9,550,918	2,894,700
1906.	15,156	(c)	1,816,631	210,000	77,373	8,963	10,620,410	3,493,643
1907.	16,888	18,418,305	2,153,873	180,025	80,994	9,159	8,772,578	2,845,663
1908.	16,322	16,586,423	2,396,217	241,868	91,388	10,010	9,770,248	3,297,988
1909.	18,578	21,916,182	2,927,975	277,911	104,019	4,279	12,048,737	4,101,976
1910.	28,519	32,050,032	4,085,076	323,239	125,013	14,759	15,244,937	4,704,088
1911.	23,993	29,545,967	3,918,556	293,301	104,160	.....	25,099,586	8,283,777
1912.	33,101	42,168,769	5,638,456	223,168	103,300	17,203	25,815,016	8,515,332
1913.	37,623	47,194,101	6,427,639	336,590	133,917	37,200	29,173,088	9,686,794
1914.	29,564	35,006,770	4,956,448	109,213	45,146	13,010	27,595,152	9,455,528
1915.	45,798	56,352,582	7,615,999	32,487	13,687	6,242	26,418,550	10,038,514
1916.	59,741	72,611,492	9,889,122	29,917	7,869	25,880	33,404,011	12,952,493
1917.	61,053	75,510,793	9,612,400	15,964	4,763	45,248	21,996,412	8,940,512
1918.	59,621	73,193,205	11,517,546	10,942	3,229	(d)29,379	17,469,500	6,927,041

(a) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (b) Comprises domestic nickel, nickel oxide, and matte. (c) Nickel content not stated. (d) Beginning July 1.

Exports of Nickel from United States, Pounds.	1914.	1915.	1916.	1917.	1918.
To France	3,457,157	3,018,354	2,283,132	1,232,142	2,233,736
To Italy	.....	.....	2,715,521	5,470,042	5,100,847
To Netherlands	855,168	129,557	516,331	.....	.....
To Russia in Europe	.....	.....	7,767,875	168,000	.....
To United Kingdom	10,836,369	14,801,565	16,674,487	14,409,272	7,803,178
To Japan	.....	890,571	245,920	275,018	2,063,933
To Russia in Asia	.....	444,374	1,148,366	.....	.....
To other countries	12,446,458	693,221	1,505,247	441,938	267,806
Total	27,595,152	26,418,550	33,404,011	21,996,412	17,469,500

Manufactures of nickel were also exported in 1918 to a value of $2,152,692.

CANADIAN PRODUCTION AND EXPORT

(Net Tons)

	1914.	1915.	1916.	1917.	1918.
Ore mined	1,000,364	1,364,048	1,566,333	1,506,828	1,643,040
Ore smelted	947,053	1,272,283	1,521,689	1,453,661	1,559,892
Bessemer matte produced	46,396	67,703	80,010	78,897	87,184
Copper content of matte	14,448	19,608	22,430	21,196	23,483
Nickel content of matte	22,759	34,039	41,298	41,887	45,886
Spot value of matte	$7,189,031	$10,352,344	$12,116,333	$12,004,141	.....

	Lb., 1914.	Lb., 1915.	Lb., 1916.	Lb., 1917.	Lb., 1918.
Nickel contained in matte, etc.:					
Exported to Great Britain	10,291,979	13,748,000	11,136,900	12,400,100	.....
Exported to United States	36,015,642	52,662,400	69,304,800	70,230,300	.....
Exported to other countries	220,706	.....	.....	.....	.....
	46,538,327	66,410,400	80,441,700	82,620,400	82,707,100

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PETROLEUM AND NATURAL GAS

By David T. Day

The year 1918 demonstrated the stability of the petroleum industry of the United States under unprecedented conditions of international stress. This is not revealed by statistical tables, unless they are coupled with the narrative of war exigencies, and compared with the instability evinced by other great industries. In fact, the point of paramount interest for the past year, and of significance for the future, is that, surrounded by the turmoil and confusion of war, and the vacillation of allied industry, the petroleum industry remained so steady that the statistical tables show less variation for this year of unparalleled demand than for those which preceded under conditions of peace.

Production under the whip of great demand increased by a trifling proportion—about 3 per cent. Exports increased by a similar slight percentage. Stocks declined significantly, and, most wonderful, petroleum ignored the war prices of other industries and stood out alone in adhering to the prices of times of peace—and this with dwindling stocks and increased demand. Another remarkable feature was the effect of foreign conditions. The public generally supposed that the war demand would be impossible of fulfillment, forgetting, maybe, that the causes which demand gasoline at the war front also paralyze the uses for the same commodity in industries at the rear. Happily, one feature offset the other to some extent. In the case of lubricating oil, industrial stagnation in France and elsewhere caused an actual decline in total exports.

In examining the outstanding feature of the industry, the amazing stability, it is beyond analytical possibility properly to accredit the result to the many, partly conflicting, agencies which beset the industry in 1918. Obviously, stability of the oil industry had been effected by long years of steady industrial growth, the credit for which must go to the great industrial corporations concerned, at the head of them the various Standard Oil companies. Through these and other thoroughly organized concerns, the appeals of the National Government for coöperation in meeting the new demands could be easily spread to the entire oil industry; and similarly the exceptional needs of the oil industry for iron and steel equipment could be efficiently met.

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The Governmental agency of prime importance was, in the first place, the Fuel Administration, with Mr. Mark L. Requa at its head, and ably supported by Mr. Thomas O'Donnell. This new organization found the industrials well equipped for coöperation, and, in fact, found coöperation well established with the Bureau of Mines in technical researches into the conservation of petroleum and its products, and in technical studies of producing, transporting and refining methods and statistical information as to the products of oil refining. This statistical work supplemented very completely the well-organized and faithfully administered statistical work in oil production carried out by the United States Geological Survey. It was a natural supposition by newly appointed experts that much remained to be done to get desired statistical information, but it was soon learned that the above agencies were proficient in the statistical field in a way leaving little to be desired. Again, the research facilities of the Bureau of Mines, carried on in highly systematized laboratories for the investigation of oil products, gave support to the new problems of war with an efficiency not previously recognized. The coöperation with the Bureau of Standards in developing standard tests of quality was also effective. In general the developed efficiency of Government oil bureaus was a gratifying surprise to the general public.

The petroleum committee of the Council of National Defense was merged into the National Petroleum War Service Committee.

At the end of 1917 these agencies found the industry beset with obstacles to development, such as great difficulty in obtaining supplies of drilling materials, especially casing, and shortage in tank cars. It was at once possible to represent the oil conditions more effectively in Washington, and to secure better allotment of the materials necessary for increasing production. In August the industry was further aided by "stabilizing" the prices of crude oil, a step which prevented the necessity of allotting gasoline and other products. On Sept. 1 a request was sent out for cessation of pleasure use of automobiles on Sundays in the region east of the Mississippi River. This was observed generally. The automobilists made it extremely unpleasant for anyone who failed to observe the request. The request really caused consumers to effect much greater saving of gasoline at all times, so that when many other necessities were limited by law as to use, and soaring as to price, the petroleum industry kept steadily on with adequate supplies, practically at peace prices.

United States Production

The statistical tables of production for 1917 and for 1918, as far as available, are given below. During the war period a host of experts were

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brought from private life to aid the Governmental bureaus. Many of these brought a fund of statistical data, more or less useful, for special studies, and a few believed they had statistical acquirements in advance of the Government's organization. This was largely due to ignorance of the broad grasp of statistical conditions and accurate use of them which the Geological Survey has developed over a period of many years; and as the special war workers have dropped away the Survey is still depended upon by the industry for its production statistics. These are now in the hands of Mr. E. Russell Lloyd, who succeeds Mr. John D. Northrop. Miss Anne B. Coons continues in charge of the statistical collection and tabulation. In the meantime, the Bureau of Mines has swung into line with a well-organized system of collecting statistics of petroleum products. This inquiry will gain by the statistical ability of Mr. J. O. Lewis, newly appointed chief petroleum technologist.

MARKETED PRODUCTION OF PETROLEUM IN THE UNITED STATES

Field	Barrels.		
	1916.	1917.	1918.
Appalachian	23,009,455	24,932,205	25,401,466
Lima-Indiana	3,905,003	3,670,000	3,220,722
Illinois	17,714,235	15,776,860	13,365,974
Oklahoma-Kansas	115,809,792	144,043,596	148,798,087
Central and North Texas	9,303,005	10,900,646	17,280,612
North Louisiana	11,821,642	8,561,963	13,304,399
Gulf Coast	21,768,096	24,342,874	21,469,419
Rocky Mountain	6,476,289	9,199,310	12,808,896
California	90,951,936	93,877,549	97,531,997
Other Fields	7,705	10,300	7,943
	300,767,158	335,315,303	355,927,716

In the 1918 figures are included 6,500,000 bbl. produced in 1917, but which remained in field storage until 1918, so that the amount may be deducted in arriving at the amount which actually came from the ground. The industry also consumed 20,500,000 bbl. drawn from pipe-line storage and 36,500,000 bbl. of crude imported from Mexico. Altogether, the requirements of the industry included, in round numbers, 400,000,000 barrels. About 340,000,000 was produced from wells in 1918, and 15 per cent. was drawn from other sources.

Prices

The prices of crude oils on Jan. 1, 1918, compared with Jan. 1, 1919, are given below.[1] After April the prices were generally controlled by the "crude stabilization" plan of the Fuel Administration:

[1] *Oil, Paint, and Drug Reporter.*

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Eastern Fields.	Jan. 1. 1918.	Jan. 1. 1919.
Pennsylvania	$3.75	$4.00
Cabell	2.72	2.77
Wooster	2.38	2.58
Corning	2.80	2.85
North Lima	2.08	2.38
South Lima	2.08	3.38
Indiana	1.98	2.28
Princeton	2.12	2.60
Somerset	2.55	2.42
Ragland	1.20	2.32
Illinois	2.12	2.42
Plymouth	2.03	2.33
Canada, Petrolia	2.48	2.78
Wyoming.		
Elk Basin	$1.85	$1.85
Grass Creek	1.75	1.85
Big Muddy	1.40	1.50
Salt Creek	1.40	1.50
North Texas Field.		
Electra	$2.00	$2.25
Henrietta	2.00	2.25
Corsicana, light	2.00	2.25
Corsicana, heavy	1.05	1.30
Strawn	2.00	2.25
Ranger	2.00	2.25

Mid-Continent.	Jan. 1. 1918.	Jan. 1. 1919.
Kansas-Oklahoma	$2.00	$2.25
Healdton	1.20	1.45
Gulf Coast.		
Spindletop	1.05	1.80
Goose Creek	1.00	1,80
Sour Lake	1.00	1.80
Humble	1.00	1.80
Batson	1.00	1.80
Saratoga	1.00	1.80
Louisiana.		
Caddo, above 38 deg	$2.00	$2.25
De Soto, above 38 deg	1.90	2.15
Caddo, 35 deg	1.90	2.15
Caddo, 32 deg	1.85	2.10
Caddo, below 32 deg	1.00	1.55
Crichton	1.50	1.75
California.		
Kern River, etc.:		
14–17.9 deg	0.98	1.23
18–18.9 deg	0.99	1.24
Ventura County:		
25–25.9 deg	1.07	1.32
Fullerton-Whittier:		
16–17.9 deg	0.98	1.23
18–18.9 deg	0.99	1.24
25–25.9 deg	1.07	1.32
37–37.9 deg	1.32	1.57

EXPORTS IN 1917 AND 1918 (a)

Product.	Gallons. 1917.	1918.
Mineral oils, total	2,651,118,340	2,714,430,451
Crude	172,118,349	205,829,030
Illuminating	658,156,487	491,109,815
Lubricating	280,437,663	257,315,632
Gasoline, naphtha	415,878,844	559,125,330
Residuum, fuel, oil, etc	1,124,524,160	1,201,050,645
Total	5,302,233,852	5,428,860,303

(a) Preliminary statement for 1918.

Contrary to the general idea that unusual quantities of oil were required abroad on account of the war, the exports showed less difference in 1918 compared with 1917 than 1916 showed over 1915. The exports of lubricating oil declined; so did illuminating oils. The chief increase was naturally in gasoline and other naphthas, while fuel oils of course gained for use in battleships.

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Standardization of Products

A definite advance for the petroleum industry was made by the formation of a committee for the adoption of specifications for the supply of petroleum and its product for any and all departments, bureaus, agencies and offices of the Government in order to avoid duplication of effort and in the interest of economy, etc. This committee included technical men of the Army, Navy, Bureau of Mines, Shipping Board, Railroad Administration and Bureau of Standards. By October the committee had adopted specifications for aviation gasoline, motor gasoline, and Navy fuel, and methods of tests were provided. Later the committee adopted tests for water-white kerosene and other burning oils for Government use. The significant effect of this work was the elimination of obsolete standards and tests, especially tests of gravity for gasoline, to the permanent benefit of the industry as a whole, as well as to the purchases of Government agencies.

Production Conditions in the Individual States

Alabama.—As this is the first State to be mentioned, attention may well be called here to the fact that the year 1918 was no year for wildcatting in questionable territory. Supplies were scarce, and the counsel of the Government agencies was to use all available drilling material to increase production in proven fields. This was probably the only reason why oil was not developed in Alabama. Detailed conditions in that State are so little known that much time and effort will be required to work the evidently favorable outlook, especially west of Birmingham.

Arizona.—In this State exploration only waited for the close of the war and the release of material, when drilling commenced in various localities, especially the Chino Valley, near Jerome; and interesting results are looked for in 1919.

California.—Production from the older fields had settled so that neither considerable losses nor gains were obtained, and the Montebello field, near Whittier, in the Southern oil district, added enough new production to effect a notable increase for the year from 93,877,549 bbl. in 1917 to over 97,500,000 in 1918. It is interesting to mark that the Coalinga, Santa Maria and Newhall-Ventura districts also showed slight increases. The decline in stocks was slight. Field operations showed an increase in most fields. Early in 1919 the Union Oil Co. completed the Chapman No. 1 well, in the Placentia district, east of Fullerton. This opens a new area of great significance. It emphasizes the fact that the Whittier-Fullerton region will be thoroughly explored as the best hope for future oil in California.

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Mr. Fletcher Hamilton, of the California State Mining Bureau, gives the following table of the quantity and value of California petroleum in recent years:

	Barrels.	Value.
1910	73,010,560	$35,749,173
1911	81,134,391	38,719,080
1912	87,272,593	39,624,501
1913	97,788,525	45,709,400
1914	102,871,907	46,292,358
1915	89,725,776	41,273,856
1916	91,976,019	57,421,334
1917	97,781,574	88,003,417
1918	101,493,752	125,000,000

On May 1 prices for all grades were increased 25 cts. per barrel, making the rates after that date as follows:

SAN JOAQUIN VALLEY FIELDS

(Kern River, Midway-Sunset, McKittrick, Lost Hills, Belridge, Coalinga.)

	Per Barrel.
14 deg. to and including 17.9 deg. gravity	$1.23
18 deg. to and including 18.9 deg. gravity	1.24
and for each increase in gravity of one full degree above 18.0 gravity, up to and inclusive of 24.9 gravity, 1 cent per barrel additional.	
25 deg. to and including 25.9 deg. gravity	1.32
and for each increase in gravity of 1 full degree above 25.0 deg. gravity, up to and inclusive of 36.9 deg. gravity, 2 cents per barrel additional.	
37 deg. to and including 37.9 deg. gravity	1.57
and for each increase in gravity of 1 full degree above 37.0 deg. gravity, 3 cents per barrel additional.	

VENTURA COUNTY

	Per Barrel.
25 deg. to and including 25.9 deg. gravity	$1.25
and for each increase in gravity of 1 full degree above 25.0 deg. gravity, up to and inclusive of 26.9 deg. gravity, 2 cents per barrel additional.	
37 deg. to and including 37.9 deg. gravity	1.57
and for each increase in gravity of 1 full degree above 37.0 deg. gravity, 3 cents per barrel additional.	

WHITTIER-FULLERTON AND SANTA MARIA FIELDS

16 deg. to and including 17.9 deg. gravity	1.23
18 deg. to and including 18.9 deg. gravity	1.24
and for each increase in gravity of 1 full degree above 18.0 deg. gravity, up to and inclusive of 24.9 deg. gravity, 1 cent per barrel additional.	
25 deg. to and including 25.9 deg. gravity	1.32
and for each increase in gravity of 1 full degree above 25.0 deg. gravity, up to and inclusive of 36.9 deg. gravity, 2 cents per barrel additional.	
37 deg. to and including 37.9 deg. gravity	1.57
and for each increase in gravity of 1 full degree above 37.0 deg. gravity, 3 cents per barrel additional.	

The proved area of California oil fields, according to the Standard Oil Co., aggregates 99,844 acres, equivalent to 141.94 square miles. In the determination, the lines were drawn 200 to 300 ft. outside of the field and in the instance of outlying single wells the field is credited with about 15 acres, thus representing the actual proved area, giving no consideration to territory generally regarded as proved but not fully drilled. Large areas in Buena Vista Hills, generally regarded as proved, are not included in the accompanying tabulation, which also shows the total production of oil in California to Dec. 31, 1918, and the total barrels per acre in the respective fields.

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TOTAL PRODUCTION, AREA, AND PRODUCTION PER ACRE OF CALIFORNIA OIL FIELDS TO DEC. 31, 1918

Field.	Proved Acreage.	Total Production to Dec. 31, 1918, Barrels.	Total Barrels per acre to Dec. 31, 1918.
Kern River	7,755	206,566,725	26,637
McKittrick	1,645	55,165,388	33,535
Midway-Sunset	40,582	325,871,087	8,030
Lost Hills-Belridge	4,675	33,846,134	7,240
Coalinga	14,916	213,155,797	14,290
Lompoc and Santa Maria	7,998	88,057,211	11,010
Ventura County and Newhall	4,904	21,311,263	4,346
Los Angeles and Salt Lake	2,700	54,300,112	20,111
Whittier-Fullerton	5,239	140,487,718	26,816
Summerland	230	2,234,947	9,717
Miscellaneous	(a) 200	992,102	4,961
Totals	90,844	1,141,988,484	12,571

(a) Estimated.

Colorado.—Definite steps for the development of the Rangley field, in Rio Blanco County, in western Colorado, was the interesting feature of the year. Before the end of the year the indications were sufficient to justify energetic drilling. Production in the old fields declined according to the following table:

PETROLEUM MARKETED IN COLORADO IN 1915–1918 (a)
(In barrels)

Month.	1915.	1916.	1917.	1918.
January	18,282	19,406	11,869	10,177
February	15,758	13,552	10,324	10,300
March	16,317	13,510	9,541	12,110
April	18,024	19,507	10,184	11,627
May	15,029	13,556	10,396	12,563
June	14,022	17,228	10,179	11,696
July	17,322	14,126	10,655	12,034
August	14,599	10,219	11,122	12,429
September	15,907	9,967	9,352	13,327
October	16,696	11,022	8,843	12,433
November	21,056	12,545	8,715	12,217
December	25,435	32,597	10,051	12,373
Total	208,475	197,235	121,231	143,286

(a) Geol. Survey figures.

Illinois.—The marked decline in production in 1917 was greater in 1918, as shown by the tables below. No new fields were developed. The wells of Lawrence, especially, are deep and have several productive sands, so that the decline will be more gradual in future years. Drilling declined to slightly more than half the wells of 1917, and those drilled yielded about the same average amount of oil per well as in 1917. Only 20 new

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wells showed more than 100 barrels initial production. Some 218 wells were abandoned, chiefly in Clark and Lawrence counties.

WELLS FOR THE YEAR

Month.	Completed.	Production.	Gas.	Dry.
January	13	248	1	3
February	5	11	1	1
March	27	308	..	9
April	38	378	1	11
May	30	454	3	7
June	41	470	..	9
July	46	978	1	13
August	49	675	..	17
September	38	950	1	10
October	25	369	..	5
November	42	498	1	12
December	42	559	..	11
Totals	396	5,898	9	108
For 1917	645	10,148	8	150
Difference	249	4,250	1	42

PETROLEUM MARKETED IN ILLINOIS, 1913–1918, IN BARRELS (a)

Month.	1913.	1914.	1915.	1916.	1917.	1918.
January	2,149,264	1,935,492	1,614,026	1,373,615	1,433,891	1,004,462
February	1,859,412	1,570,790	1,542,383	1,330,016	1,197,208	1,031,472
March	2,008,245	1,969,915	1,761,099	1,552,827	1,433,503	1,215,240
April	2,015,058	1,833,099	1,643,479	1,396,454	1,308,421	1,145,106
May	2,117,425	1,970,688	1,638,733	1,572,217	1,424,664	1,216,235
June	2,003,278	1,932,303	1,603,733	1,527,589	1,335,105	1,125,684
July	2,075,444	1,907,521	1,636,932	1,540,887	1,369,048	1,193,233
August	2,001,228	1,844,983	1,593,436	1,561,066	1,364,809	1,127,151
September	1,942,052	1,817,437	1,535,040	1,467,892	1,263,864	1,089,608
October	1,982,002	1,813,364	1,533,972	1,522,930	1,305,032	1,139,493
November	1,819,116	1,678,783	1,452,285	1,454,302	1,245,588	1,018,577
December	1,921,375	1,645,374	1,486,577	1,414,440	1,089,508	1,059,713
	23,893,899	21,919,749	19,041,695	17,714,235	15,770,641	13,365,974

(a) Geol. Surv. figures.

Indiana.—A few more wells were drilled than in 1917, chiefly on account of a few fair results on the western edge of the State, near Princeton and Oakland City. The decline proceeded as usual. Only 135 wells were abandoned, against 966 in the previous year.

WELLS BY MONTHS

Month.	Completed.	Production.	Gas.	Dry.
January	6	60	..	..
February	12	340	1	4
March	27	469	..	10
April	18	406	2	5
May	18	304	..	10
June	36	464	1	13
July	37	447	..	17
August	25	234	1	12
September	29	374	2	7
October	14	546	..	2
November	32	683	1	13
December	22	251	..	8
Totals	276	4,578	8	101
For 1917	267	4,919	9	84
Difference	9	341	1	17

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PETROLEUM MARKETED IN INDIANA, 1912–1918, IN BARRELS

Month.	1912. (a)	1913. (a)	1914. (a)	1915. (a)	1916. (a)	1917. (a)	1918. (a)
January	64,403	73,237	109,891	82,390	57,063	64,259	48,779
February	62,991	70,336	97,045	85,690	60,731	54,593	64,546
March	81,148	57,204	120,508	76,939	61,260	59,497	75,724
April	92,965	78,764	126,670	82,683	63,195	62,038	80,677
May	101,102	77,379	128,493	75,922	69,660	67,327	85,353
June	85,819	73,056	129,855	78,934	69,725	63,306	75,621
July	90,011	73,838	121,122	72,189	66,191	65,120	81,295
August	86,492	72,467	109,939	66,452	72,841	65,527	75,955
September	78,432	81,462	110,299	62,010	67,462	62,992	67,835
October	83,634	91,368	105,969	66,332	65,937	70,282	77,124
November	69,733	98,444	88,272	58,447	57,596	67,808	72,692
December	73,279	108,549	87,393	67,770	57,375	56,683	71,957
Total	970,009	956,095	1,335,456	875,758	769,036	759,432	877,558

(a) Geol. Surv. figures.

Kentucky.—This State was the center of drilling interest for the entire East during 1918. Not only were more wells drilled than in any other eastern State, but it must be noted that while in Pennsylvania drilling means simply "threshing over old straw," Kentucky offers really great areas of virgin territory, and the wells above 200 bbl. initial production have been many, and widely separated. In 1917 it was Estill County that concentrated attention, while in 1918 wildcatting was carried on in 53 counties, and 2167 wells were drilled, of which only 353 failed to produce oil. Lee, Allen, Powell and Estill were the counties of chief interest. Activity is increasing in 1919 because pipe-line facilities are catching up with production. The Cumberland Pipeline Co. extended lines in Estill, Lee, Powell, Beathitt and Jackson counties. The National Refining Co. extended a 4-in. line between Big Sinking Field and Beattyville. But, with the Old Dominion and other added lines, the pipeage is insufficient. Much oil is sent to road loading racks by small gathering lines. In the western part of the State, from the Johnson pool in Allen County, the Indian Refining Co. has put in a line to Scottsville, whence the oil goes by tank cars to the refinery. This company has various other gathering lines. Even with lines of the American Pipeline Co. and the Daniel Boone Oil Co., the production is still not taken care of. Four refineries are under construction in the western part of the State, and during the summer oil barges will take much oil to Louisville by way of the Barren, Green and Ohio rivers, which are navigable from Bowling Green. There have been many obstacles to all this work, including poor titles to some of the land; also the fact that deeper sands are preferred on account of better lasting qualities where large transportation expense is involved.

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DRILLING IN 1918

Month.	Completed.	Production.	Gas.	Dry.
January	77	718	6	17
February	102	1,930	4	23
March	153	1,674	5	34
April	176	2,132	2	28
May	171	2,031	4	27
June	161	2,553	5	26
July	248	4,429	2	38
August	208	4,792	4	30
September	220	6,037	11	30
October	217	5,648	14	38
November	174	6,469	5	34
December	260	10,166	16	28
Totals	2,167	48,606	78	353
For 1917	1,648	35,204	61	422
Difference	519	13,402	17	69

PETROLEUM MARKETED IN KENTUCKY, 1913-1918, IN BARRELS (a)

Month.	1913.	1914.	1915.	1916. (a)	1917. (a)	1918. (a)
January	42,074	46,930	34,898	33,751	154,378	265,223
February	36,843	44,545	35,707	40,657	139,417	287,524
March	39,390	53,860	39,562	51,323	174,299	322,479
April	39,036	50,465	40,015	65,545	165,331	312,322
May	42,903	44,903	39,323	86,102	240,024	316,164
June	39,285	44,361	37,070	81,409	266,328	305,571
July	48,211	42,630	35,905	94,001	318,776	355,899
August	49,908	26,758	37,531	134,432	320,529	383,467
September	52,538	21,177	34,929	143,093	330,626	415,451
October	46,301	51,625	33,564	162,060	352,481	448,363
November	44,137	36,900	34,702	157,685	339,783	459,876
December	43,911	38,287	34,068	153,188	286,188	495,629
	524,568	502,441	437,274	1,203,246	3,088,160	4,367,968

(a) U. S. Geol. Surv. figures. Includes a small amount from Tennessee.

Louisiana.[1]—The Pine Island pool caused a notable increase in production in northern Louisiana, from 8,368,025 bbl. in 1917 to 12,900,470 in 1918. Just at the close of 1917 the Texas Oil Co. brought in a 10,000-bbl. gusher on Pine Island which had such high pressure as to defy control for weeks. The excitement provoked the usual drilling boom, and over 300 wells were drilled during the year, with a small proportion of dry holes. The field is 5 miles long, paralleling Black Bayou, and 4 miles wide. It obtains the oil at various depths between 1500 and 2300 ft. A drawback developed in lack of transportation facilities. It was still markedly felt in 1919. The signing of the armistice brought an immediate canceling of Government orders for heavy oil for fuel for this country and for the Allies, so that the Standard Oil Co., which had furnished the chief pipe-line outlet for the oil, found itself with no outlet for this grade of oil. They offered, however, their tank storage up to 200,000 bbl. for the Pine Island crude, enough to last 18 days. The Texas Co. early in December declined to take Pine Island crude from any new companies, but offered to pro-rate its own shipments with existing customers. A delegation of producers laid the matter before the Washington authorities late in December. Soon after this

[1] Statistical information from *Oil, Paint, and Drug Reporter.*

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the producers agreed to accept a 30-ct. per bbl. cut, restrict production, and pro-rate the output. Soon after the close of 1918 an important strike of a new pool was made in Claiborne Parish, to the east of the Caddo region. It is known as the Homer pool. The oil is light, and the find of much interest.

DRILLING SYNOPSIS FOR 1918, NORTH LOUISIANA

Field.	Oil.	Dry.	Gas.	Total.	New Production, Barrels.
Caddo	368	35	13	416	172,745
De Soto	14	4	1	19	2,530
Red River	6	.....	1	7	230
Bossier	5	2	12	19	335
Miscellaneous	9	64	.....	73	178
Total, 1918	402	105	27	534	176,028
Total, 1917	316	152	.....	468	67,043
Difference	96	47	.....	134	118,985

PRODUCTION BY FIELDS IN BARRELS

1918.	Caddo, Light.	Caddo, Heavy.	De Soto-Red River.	Total.
January	252,700	142,750	166,500	561,950
February	295,200	189,900	174,875	659,975
March	305,760	210,385	177,350	693,495
April	354,850	361,900	199,150	915,900
May	359,365	486,460	193,940	1,039,765
June	361,350	662,275	201,850	1,225,475
July	401,125	675,550	210,025	1,286,700
August	402,285	765,830	193,675	1,361,790
September	386,890	728,150	195,870	1,310,910
October	356,545	750,125	185,750	1,292,420
November	347,245	748,250	180,125	1,275,620
December	345,970	750,350	180,250	1,276,570
Total:				
1918	4,169,285	6,471,925	2,259,360	12,900,470
1917	4,269,955	1,134,505	2,963,565	8,368,025
Difference	100,670	5,337,420	704,205	4,541,345

PRODUCTION OF STATE IN BARRELS

Northwest Louisiana, 1918	12,900,470
South Louisiana, 1918	2,523,050
Total, State of Louisiana, 1918	15,423,520
1917	11,334,900
Increase, 1918	4,088,620

Ohio.—In southeastern Ohio the high cost of drilling deterred all development work except within proved areas, where the operator could safely figure even a small profit. This was equally true in the central Ohio field, where the interest is chiefly in keeping up the natural-gas supply. Northeastern Ohio showed some signs of life when a few wells were obtained near Ashtabula. The old Lima field in northwestern Ohio continued sporadic drilling, but with no new development. The State will show an increase in 1919 when drilling costs approach normal. The usual field reports show little change from conditions in 1917:

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DRILLING IN OHIO

Month.	Southeastern Ohio.				Central Ohio.					Northwestern Ohio.			
	Completed.	Production.	Gas.	Dry.	Completed.	Wells, Oil.	Production, Oil.	Gas.	Dry.	Completed.	Production.	Gas.	Dry.
January	37	434	3	5	55	1	25	45	9	15	188	....	.....
February	51	760	1	15	36	2	75	29	5	5	62	....	1
March	64	278	1	20	40	2	130	22	16	31	324	....	2
April	108	1,012	2	39	35	2	90	24	9	35	379	....	2
May	109	1,165	4	30	61	5	123	38	18	59	530	1	9
June	119	879	7	23	68	4	202	39	25	40	551	3	1
July	113	892	9	30	46	5	310	25	16	52	594	1	7
August	101	738	9	23	56	7	238	37	12	47	638	....	2
September	98	919	2	26	54	6	148	33	15	33	695	....	7
October	100	1,324	6	20	45	11	184	25	9	28	570	....	2
November	94	533	5	27	62	9	601	44	9	41	486	8	4
December	91	848	6	26	47	9	86	22	16	31	470	....	2
Totals	1,085	9,782	55	284	605	63	2,212	383	159	417	5,487	8	39
For 1917	1,246	11,278	55	356	582	37	901	407	138	535	7,385	9	52
Difference	161	1,496	....	72	23	26	1,311	24	21	118	1,898	1	13

PETROLEUM MARKETED IN OHIO 1912–1918, IN BARRELS (a)

Month.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
January	587,871	744,203	785,588	653,673	603,044	640,318	444,890
February	602,747	640,138	592,847	635,550	597,302	560,971	530,942
March	760,741	603,816	808,089	709,525	672,958	688,923	652,055
April	807,680	805,276	787,654	699,202	642,684	648,595	639,715
May	834,201	754,623	765,522	645,119	689,248	701,091	678,707
June	770,561	732,174	759,813	672,723	699,879	679,078	612,126
July	804,975	752,144	793,570	658,404	654,804	676,932	664,165
August	818,621	729,945	515,146	633,241	678,916	688,085	637,483
September	732,376	744,466	611,574	630,554	626,277	617,732	584,032
October	791,758	789,356	821,557	642,166	648,893	674,708	651,688
November	710,490	702,108	648,586	603,897	634,452	633,393	572,775
December	746,986	783,219	646,406	641,272	596,054	540,714	616,427
	8,969,007	8,781,468	8,536,352	7,825,326	7,744,511	7,750,540	7,285,005

(a) Geol. Surv. figures.

Pennsylvania and New York.—In spite of its age, this region finished 2006 wells, with only 216 dry holes. Only 15 new wells gave over 100 bbl. initial production. Nine of these were in Greene County; the others were in Allegheny and Clarion counties.

WELLS IN 1918

Month.	Completed.	Production.	Gas.	Dry.
January	78	138	10	9
February	79	215	11	9
March	134	326	13	14
April	167	490	12	26
May	202	350	26	26
June	215	417	25	26
July	213	124	18	25
August	193	499	16	19
September	188	537	24	7
October	197	424	21	19
November	165	416	20	13
December	175	356	15	23
Totals	2,006	4,592	211	216
For 1917	2,580	9,531	265	353
Difference	574	4,939	54	137

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PETROLEUM MARKETED IN PENNSYLVANIA AND NEW YORK, 1913–1918 (a).
(In barrels.)

PENNSYLVANIA

Month.	1913.	1914.	1915.	1916.	1917.	1918.
January	669,134	677,284	629,588	625,720	641,092	502,185
February	577,763	532,826	615,005	555,410	555,525	557,564
March	637,250	726,605	672,343	625,987	712,735	668,325
April	703,829	782,378	697,036	662,241	672,875	647,535
May	700,585	701,685	638,490	701,435	711,358	690,420
June	661,542	724,172	683,410	658,195	686,789	611,681
July	688,055	731,080	682,583	641,148	670,550	663,988
August	653,090	646,412	655,242	663,901	665,484	632,108
September	651,046	688,761	654,036	609,754	610,115	589,584
October	693,996	704,024	645,333	638,244	645,981	657,463
November	609,033	614,126	623,955	605,049	608,631	583,933
December	671,979	640,982	641,684	605,310	552,065	603,026
	7,917,302	8,170,335	7,838,705	7,592,394	7,733,200	7,407,812

NEW YORK

January	80,906	78,983	74,101	72,216	74,332	48,753
February	66,969	62,424	67,755	61,611	59,615	57,530
March	74,592	80,660	79,840	64,906	81,305	73,414
April	82,580	88,268	79,018	79,439	71,511	68,983
May	83,742	84,548	75,114	80,140	81,371	77,429
June	77,819	84,110	76,408	78,586	80,232	68,681
July	83,237	84,783	79,012	79,489	75,270	70,541
August	78,005	75,512	72,531	76,552	76,836	72,582
September	78,594	76,102	72,914	72,946	71,247	70,027
October	84,480	81,569	72,399	73,056	74,836	67,776
November	74,437	71,593	66,218	68,351	67,106	64,650
December	82,830	70,422	72,468	69,792	66,024	68,477
	948,191	938,974	887,778	874,087	879,685	808,843

(a) Geol. Surv. figures.

The Mid-Continent Field.—Oklahoma declined slightly in output, but Kansas more than made up the deficit. Together these two States increased from 144,043,596 bbl. in 1917 to 148,798,087 bbl. in 1918. Oklahoma gave place to California as the leading oil-producing State.

In 1915 Oklahoma produced almost 118,000,000 barrels. Now it has declined to 103,347,070 bbl., and this in spite of the fact that 8367 wells were drilled, or 1691 more than in 1917. The resulting new production was slightly greater than in 1917, but in no way offset the great decline which affected all fields except Garfield-Noble. The Garber pool, in Garfield County, was extended, as was the Osage territory, and the Youngstown pool in Okmulgee County and the Mervine pool in Kay County were developed.

In Kansas the great increase of 1917 continued to a maximum in April; then a decline began, quite slow at first, but more rapid toward the end of the year. Altogether, the State's output increased from approximately 36,536,125 bbl. in 1917 to 45,451,017 in 1918. Its product now is almost exactly half that of Oklahoma. (In 1915 Oklahoma produced 25 times as much oil as Kansas.) The product was chiefly from the new Eldorado and Augusta fields.

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PETROLEUM MARKETED IN OKLAHOMA AND KANSAS, 1916–1918 (a)

(In barrels)

Month.	Oklahoma.			Kansas.		
	1916.	1917.	1918.	1916.	1917.	1918.
January	8,564,301	8,441,229	8,048,966	197,348	2,199,862	3,855,322
February	7,929,890	8,763,238	7,768,787	284,726	1,739,952	3,404,699
March	9,474,878	9,631,738	8,953,389	353,693	2,498,789	4,070,370
April	8,938,605	8,621,433	8,098,833	441,422	2,323,291	4,238,706
May	8,963,599	9,355,086	8,740,788	633,726	2,366,411	4,089,150
June	8,995,842	9,047,460	8,521,536	834,640	2,681,568	4,113,295
July	9,563,613	8,750,160	9,128,313	705,376	3,009,914	4,490,257
August	9,041,907	8,474,831	8,460,355	644,667	3,610,946	4,174,275
September	9,012,971	8,761,698	8,725,095	951,516	4,101,561	4,042,394
October	9,560,032	9,399,483	9,108,068	1,260,585	4,116,002	3,529,384
November	9,143,094	8,797,850	9,141,404	1,212,459	4,304,013	2,955,341
December	8,318,739	9,027,509	8,651,536	1,217,919	3,583,816	2,487,824
Total	107,507,471	107,071,715	103,347,070	8,738,077	36,536,125	45,451,017

(a) U. S. Geol. Surv. figures.

PRODUCTION BY DISTRICTS, 1917 AND 1918

Oklahoma.	1917. Barrels.	1918. Barrels.	Kansas. (a)	1917. Barrels.	1918. Barrels.
Cushing	26,739,628	20,993,159	El Dorado	19,915,569	29,198,145
Glenn	7,906,245	5,387,885	Augusta	11,353,600	6,871,525
Healdton and Wheeler	18,353,530	15,695,322	Outside districts	6,717,500	7,183,800
Other	54,508,068	61,270,704	Total	37,986,669	43,253,470
Total	107,507,471	103,347,070			

(a) Approximate figures only.

WELLS DRILLED IN 1918

Month.	Oklahoma.				Kansas.			
	Completed.	Production.	Dry.	Gas.	Completed.	Production.	Dry.	Gas.
January	442	20,029	118	39	232	16,879	44	10
February	445	27,592	108	36	212	23,937	41	18
March	709	37,168	153	57	352	62,748	75	18
April	784	36,179	184	53	475	34,986	109	16
May	789	47,975	162	64	502	35,723	84	21
June	1,003	41,466	234	102	546	46,785	106	17
July	626	30,402	149	58	493	47,895	87	26
August	792	28,549	225	74	473	26,534	99	29
September	704	27,873	194	75	372	11,994	80	30
October	709	24,535	189	64	382	15,364	78	20
November	719	31,250	230	73	303	9,085	62	48
December	645	19,290	163	58	330	10,942	60	19
Totals, 1918	8,367	372,308	2,100	753	4,671	342,872	925	272
Totals, 1917	6,676	361,463	1,292	397	3,469	325,410	559	174
Difference	1,691	10,845	817	356	1,202	17,462	366	98

Tennessee.—The reasons given for failure to explore Alabama apply to Tennessee—too great use for the limited drilling supplies in more certain regions. Some drilling was done in Dickson and Montgomery counties, without definite result. In all 17 producing wells were drilled in the year, with 3 gas wells. Much geologic work has gone on which will guide more drilling 1919.

The finished wells in Tennessee during 1918 were, by months, as follows:

Month.	Completed.	Production.	Gas.	Dry.
February	2	..	..	2
April	4	90		..
June	1	3	..	..
September	12	155	2	2
October	1	5	..	..
November	4	5	..	3
Totals	24	258	3	7
For 1917	11	615	2	1
Difference	13	357	1	6

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Texas.—North Central Texas, including the Burk-Burnett, Electra and Ranger fields, among others, constitute the one great hope of keeping up the oil supply of the United States above 300,000,000 bbl. a year. Included in the hope is the stimulus given by the above fields to the search for others in the State. This sufficed in 1918 to cause drilling in many other counties in Texas which would not have been noticed.

PETROLEUM MARKETED IN TEXAS, 1914–1918 IN BARRELS (a)

Month.	1914.	1915.	1916.	1917.	1918.
January	1,503,652	1,590,719	2,534,816	2,490,321	2,729,057
February	1,392,109	1,727,168	2,287,240	2,319,909	2,493,332
March	1,726,475	1,818,055	2,326,434	2,561,228	2,862,133
April	1,860,873	1,820,619	2,199,299	2,694,849	2,807,253
May	1,878,982	1,738,578	2,482,606	2,627,671	3,069,292
June	1,865,029	1,774,338	2,349,883	2,665,455	3,172,895
July	1,720,868	1,958,288	2,309,750	2,977,669	3,357,098
August	1,695,372	1,834,068	2,273,733	3,049,157	3,353,566
September	1,621,551	2,215,396	2,165,394	3,025,273	3,523,821
October	1,720,646	2,729,713	2,249,438	2,875,142	3,551,548
November	1,566,217	3,137,359	2,068,674	2,413,797	3,583,324
December	1,516,410	2,598,400	2,397,338	2,712,816	4,246,712
	20,068,184	24,942,701	27,644,605	32,413,287	38,750,031

(a) Geol. Surv. figures.

The production in the North Texas field amounted to 17,280,612 bbl., an increase of 58 per cent. over 1918.

The Gulf region in Texas made great effort to extend the pools, especially by deeper drilling. The results were only sufficient to lead the work along; 1677 new wells were completed, or 117 more than in 1917. The production from these new wells was markedly less. Production declined generally, in spite of development of the Hull, Barber's Hill and Columbia pools. The following table shows the total production for each district of the South Texas district of the Gulf Coast for the year 1918 (in barrels), year 1917, and the total increase or decrease of each district for 1918, as compared with 1917.

SOUTH TEXAS PRODUCTION IN BARRELS

District.	1917.	1918.	Difference.
Batson	693,075	621,075	72,540 dec.
Damon Mound	494,710	382,060	112,640 dec.
Dayton	29,170	8,270	10,900 dec.
Goose Creek	7,623,270	8,510,780	887,510 inc.
Humble	7,115,160	5,367,070	1,748,090 dec.
Hull	.....	283,400	.....
Markham	148,320	90,250	58,070 dec.
Piedras Pintas	40,130	48,490	8,360 inc.
Saratoga	702,405	717,560	15,155 inc.
Sour Lake	4,794,530	3,299,190	1,495,340 dec.
Spindletop	375,505	560,620	185,115 inc.
W. Columbia	.....	65,680	.....
Totals	19,954,445	22,083,420	2,128,975

Washington.—The Standard Oil Company of California has acquired some eight thousand acres of land lying north and south of Moclips,

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which is near the Quienialt Indian Reservation, north of Gray's Harbor, Washington. It is expected that drilling on this tract will commence in the near future.

West Virginia.—Only 1309 wells were finished in West Virginia, against 1637 in 1917, but the initial production from the smaller number equalled that of the greater number of wells in 1917. Meantime, the older wells declined, showing a net loss for the State from 8,379,285 bbl. in 1917 to 7,866,628 in 1918. The Columbian Carbon Co. undertook to deepen a gas well in the Kelly's Creek district, Kanawha County, and brought in a gusher the excitement from which caused drilling enough to give the pool a production of 3000 bbl. a day. No other new pool was obtained. Present high costs have discouraged the deep drilling upon which further increases in West Virginia will probably depend.

DRILLING IN 1918

Month.	Completed.	Production.	Gas.	Dry.
January	69	413	15	18
February	67	1,007	21	9
March	100	835	21	18
April	107	724	23	19
May	109	676	27	20
June	117	880	32	16
July	121	702	32	22
August	131	3,592	31	24
September	134	1,300	36	27
October	132	1,337	34	25
November	122	2,548	32	21
December	100	777	26	19
Totals	1,309	14,791	330	238
For 1917	1,637	14,711	433	257
Difference	328	80	103	19

PETROLEUM MARKETED IN WEST VIRGINIA, 1913–1918 (a)
(In Barrels)

Month.	1913.	1914.	1915.	1916.	1917.	1918.
January	978,401	855,886	777,702	647,805	700,840	589,538
February	936,733	770,300	754,034	672,843	617,115	631,042
March	970,900	919,377	848,926	751,018	731,373	659,099
April	1,026,129	900,998	801,046	674,056	669,982	685,714
May	1,003,425	864,519	767,685	765,938	739,808	703,016
June	995,098	872,074	789,545	737,701	684,290	625,727
July	1,009,383	897,065	780,749	704,071	684,461	687,305
August	939,479	272,098	761,111	749,881	704,155	644,511
September	928,610	675,518	752,751	706,416	702,030	640,237
October	956,772	985,724	716,638	783,475	760,430	684,122
November	893,274	799,728	720,267	786,723	700,231	640,551
December	983,095	866,746	794,344	751,257	684,570	675,766
	11,567,299	9,680,033	9,264,798	8,731,184	8,379,285	7,866,628

(a) Geol. Surv. figures.

Wyoming.—The geologic work in Wyoming in 1917 bore fruit in 1918 by an increase from 9,460,000 bbl. in 1917 to 12,596,287 bbl. in 1918. This total will increase rapidly when passage of the leasing bill clears

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up the relations of would-be producers to the National Government on withdrawn lands. The leasing bill failed of adoption at the end of the last congress, although the conference committee agreed upon a report. As agreed to, a claimant who had developed a producing well should have the right to lease it. Everything was adopted that the Navy Department and Department of Justice asked for. On past production a royalty of one-eighth was required; and on future production, not less than one-eighth royalty.

The other needs of the industry are better refining facilities, and still greater refining capacity. Outside of the well-defined Salt Creek field, the regions of the chief drilling interest were the Big Muddy, Lander, and Big Horn Basin fields. The Tisdale dome was a disappointment, showing salt water in the Shiloh well. The Curtis and New York companies did interesting drilling on very good structure in the oil mountain district. Three wells on the Iron Dome of this company gave large yields of natural gas, which will probably be piped to Casper. In the Big Horn Basin, considerable drilling was done, and the Warm Springs field was developed. The oil was piped to the Greybull refinery. The Ohio Oil Co. has developed a field near Rock River, and a refinery is being constructed rapidly. A flowing well was struck on the Ferris Dome by the Producers' and Refiners' Co. The Lusk or Lance Creek development, in Niobrara County, is also justifying attention. Refinery and pipeline development was very active, the Standard and Midwest Refining companies doubling their capacity during the year.

PETROLEUM PRODUCTION OF WYOMING

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1894	2,369	1902	6,253	1911	186,695
1895	3,455	1903	8,960	1912	1,572,306
1896	2,878	1904	11,542	1913	2,406,522
1897	3,650	1905	8,454	1914	4,306,000
1898	5,475	1906	7,000	1915	4,245,525
1899	5,560	1907	9,339	1916	6,234,137
1900	5,450	1908	17,775	1917	8,978,680
1901	5,400	1909	22,131	1918	12,596,287
		1910	115,430		

WELLS DRILLED IN 1918

Month.	Completed.	Production.	Gas.	Dry.
January	5	500	..	..
February	3	....	2	1
March	20	1,100	1	12
April	12	795	2	3
May	21	2,175	2	10
June	19	3,765	2	4
July	22	2,865	4	5
August	21	3,289	1	2
September	60	6,286	5	18
October	26	2,924	3	3
November	34	2,975	6	3
December	15	1,045	1	4
Totals	258	27,709	29	65

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TOTAL OUTPUT OF REFINERIES IN THE UNITED STATES FOR 1917

Month.	Run to Stills.		Gasoline, Gallons.	Kerosene, Gallons.	Gas and Fuel, Gallons.	Lubricating, Gallons.	Wax, Pounds.	Coke, Tons.	Asphaltum, Tons.	Miscellaneous, Gallons.	Losses, Barrels.
	Crude, Barrels.	Other Oils, Barrels.									
January	24,839,772	(1)	203,618,724	137,248,370	469,596,208	60,941,062	39,558,627	44,627	49,894	27,331,019	941,924
February ...	23,083,433	(1)	184,602,595	129,074,504	446,964,925	54,631,765	36,370,297	42,047	40,619	23,685,686	941,110
March.....	26,230,138	(1)	220,523,571	159,028,978	494,855,838	64,345,221	40,868,930	48,839	52,823	26,977,334	870,380
April.....	25,994,938	(1)	228,945,164	157 826,945	462,846,339	63,218,215	41,037,511	46,099	52,849	30,959,901	957,533
May.....	27,253,391	(1)	238,816,209	147,894,846	504,859,695	65,926,007	38,686,364	43,535	67,612	31,086,377	979,245
June.....	26,453,210	(1)	233,671,746	151,477.333	496,742,434	61,045,757	38,269,670	42,513	67,931	30,205,172	1,011,568
July.....	26,776,856	2,435,533	244,145,292	161,679,053	599,454,966	64,335,905	38,075,280	42,641	65,272	92,359,401	1,111,511
August.....	27,900,623	2,376,580	254,464,491	149,528,513	632.151,971	64,107,817	40,158,033	46,240	73,878	92,708,312	1,286,141
September...	27.529,022	2,632,988	256,132,050	143,203,644	629,914,572	60,757,049	38,999,341	42,986	62,520	80,386,471	1,182,560
October.....	27,698,023	2,863,518	271,891,234	140,559,542	621,492,374	68,516,071	48,300,033	48,849	73,886	91,804,160	1,355,219
November...	26,215,979	2,519,700	264,888,709	125,893,202	592,490,037	64,861,375	41,181,400	45,815	73,289	87,115,002	1,203,110
December....	25,155,996	2.069,351	248,846,638	123 354,046	561,954,921	61,090,596	39,694,595	45,175	58,852	87,548,408	1,233,528
Total.....	315,131,681	14,897,670	2,850,546,423	1,726,768,976	6,513,324,280	753,776,840	481,200,081	539,366	739,425	702,167,243	13,073,829

TOTAL OUTPUT OF REFINERIES IN THE UNITED STATES FOR 1918

	Barrels.	Barrels.	Gallons.	Gallons.	Gallons.	Gallons.	Pounds.	Tons.	Tons.	Gallons.	Barrels.
January.....	23,842,587	2,300,334	242,632,044	119,358,184	547,866,248	56,623,425	39,238,858	41,216	54,854	70,995,829	1,078,181
February	23,386,676	2,298,333	234,324,619	121,218,320	510,165,397	58,300,914	35,087,337	42,371	42,033	75,134,088	983,992
March.....	26,239,662	3,696,872	269,627,968	151,288,007	587,985,804	69,308,351	43,597,019	44,248	56,901	94,865,148	1,097,489
April.....	26,201,544	3,956,244	293 396,162	153.703,682	578,255,341	71.022,204	40,137,524	45,674	51,242	89,242,012	1,182,020
May.....	28,510,698	4,112,023	319,931,202	160,590,760	631,686,209	79,589,735	42,544,633	48,864	60,449	88,627,491	1,269,281
June.....	28,140,479	3,483,270	315,023,445	151,840,252	628,842,033	74,420,996	41,317,794	46,605	50,321	81,110,922	1,282,177
July.....	29,170,718	5,951,537	332,022,095	156,828,826	658,439,682	79.303,107	41,691,551	48,914	58,433	159,374,139	1,338,304
August.....	28,534,275	6,376,353	330.325,046	149,678,850	671,113,871	72,892,879	41,829,516	51,759	59,715	163,345,634	1,337,327
September...	28,390,431	5,485,747	314,595,959	164,963,798	653,085,050	70,593,079	42,704,894	48,052	49,157	138,201,963	1,236,834
October.....	29,237,767	5,571,847	314,251,318	164,928,640	661,780,441	72,244,633	43,470,132	48,820	51,878	166,109,867	1,161,545
Total.....	271,654,837	43,332,560	2,965,599,858	1,494,339,319	6,129,120,076	704,299,323	411,655,258	466,523	534,983	1,127,005,993	11,967,150

(1) No account during first 6 months of 1917.

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Refining Statistics

For the first time in the history of the United States, complete statistics of refining have been collected and published, by the Bureau of Mines. They form an efficient complement to the statistics of production collected by the United States Geological Survey.

Oil Possibilities in Other States

Montana.—C. F. Bowen, of the United States Geological Survey, has investigated the anticlines in a part of the Musselshell Valley in south central Montana. The geologic formations which yield oil in the Big Horn Basin exist in Musselshell Valley, and this caused the drilling of several wells. In his report[1] Mr. Bowen describes eight rock arches and domes in which oil might possibly accumulate, and he points the best places for test holes. The report contains a map of about 1200 sq. mi. in that region.

In Teton and Lewis and Clark counties, northwestern Montana, Mr. Eugene Stebinger has made a similar examination[2] published as "Oil and Gas Geology of the Birch Creek-Sun River Area." It shows that the formations that yield most of the oil produced in Wyoming and all of the gas produced in southern Alberta underlie nearly all of this area, and at places where the oil-bearing formations crop out at the surface the indications of oil are rather more numerous in northwestern Montana than in the oil-bearing regions of Wyoming. None of the wells drilled in this area can be considered fair tests for oil, because they have either been located without regard to the local structural features or have not been carried deep enough to reach the most promising formations. There is therefore no valid reason for classing the plains of northwestern Montana as barren of oil until they have been fairly tested by the drill. One fold or anticline near Willow Creek, in this area, seems to be especially favorable for "wildcat" drilling. It is suggested that the initial test of this possible oil trap can probably be best made on its crest near the line between secs. 19 and 30, T. 24 N., R. 5 W.

Arkansas.—Several asphalt deposits in Pike and Sevier counties, in southwestern Arkansas, have from time to time attracted the attention of persons interested in oil, some of whom have at different times leased land in these and adjoining counties and sunk wells in the hope of finding oil. In none of these wells, however, has oil been found in commercial quantity.

[1] *Bull.* 691-F, U. S. Geol. Surv.
[2] *Bull.* 691-E, U. S. Geol. Surv.

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Asphalt was mined several years ago from a deposit near Pike, in Pike County, and shipped to Little Rock, where it was used in paving streets. This and the other asphalt deposits in the two counties named and the possibility of finding oil in these and adjoining counties are discussed by H. D. Miser and A. H. Purdue in a report entitled "Asphalt Deposits and Oil Conditions in Southwestern Arkansas."[1] The report gives the records of several deep wells which have been drilled in recent years for oil and for artesian water, and these records will be of special interest to those who expect to drill deep wells in this part of the State.

North Dakota.—Natural gas is now produced in North Dakota, but oil has not yet been found there in commercial quantities. Whether the failure to find oil is due to the barrenness of the beds tested by the drill or to the unfavorable situation of the few wells that have been drilled is not known. In North Dakota the beds lie so nearly flat that domes and arches can ordinarily only be detected by a detailed geologic survey. Nevertheless the reported occurrence of a small flow of gas from an artesian well drilled about 3½ miles west of the crest of an anticline near Nesson, in the northwest corner of North Dakota, about 30 miles east of Williston, is of interest and possibly of significance to well-drillers as well as to the residents of that region. This anticline is a very broad, flat arch in which the dip of the strata on either side is less than 1°.

The driller of this artesian well reports that he struck, at a depth of 750 ft., a small flow of gas which could be burned as it came to the surface. A well drilled nearer the crest of this anticline might strike a good flow of gas in the Tertiary rocks within 700 ft. of the surface, but in order to test this or any other anticline in this region for oil it will be necessary to drill a deeper well near its crest, at least to the Cretaceous rocks, the top of which lies at a depth of about 1700 ft. If carried to the Dakota sandstone, which here lies at a depth of about 3700 ft., such a well would test the horizons in the Cretaceous at which oil has been found in Wyoming.

A report entitled "The Nesson Anticline, Williams County, North Dakota," by A. J. Collier, has been published by the U. S. Geological Survey as *Bulletin* 691-G.

Natural Gas

The depletion of the natural-gas supplies in Ohio, Indiana and other mid-western States was felt more keenly in 1918 than ever before. Nevertheless, the general decline for the country was not what it was expected to be, on account of the great number of natural-gas wells brought in in the effort to keep up the petroleum supply, especially in Pennsylvania,

[1] *Bull.* 691-J, U. S. Geol. Surv.

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West Virginia, the new fields in Kentucky, and in the Texas developments. The following table shows the number of new natural-gas wells drilled in 1918, and the total cubic feet per day obtained in each State:

State.	Number of Wells.	Production, Cubic Feet per Day.
Pennsylvania	78	175,000,000
West Virginia	330	1,442,000,000
Southeast Ohio	22	43,000,000 (select wells)
Central Ohio	383	686,130,000 (initial volume)
Northwest Ohio	8	(a)
Indiana	8	3,000,000 (3 gushers)
Illinois	9	2,500,000 (2 gushers)
Kentucky	78	46,500,000 (30 gushers)
Tennessee	3	(a)
Texas (North Central)	26	341,500,000 (26 gushers)
North Louisiana	27	703,500,000 (all wells—53)
Wyoming	29	280,000,000 (20 gushers)
Oklahoma	753	(a)
Kansas	272	(a)

(a) Not available.

The collection of the statistics of production of natural gas is carried out in the most exact and painstaking manner by the United States Geological Survey, and by no other general agency in the United States.

NATURAL GAS PRODUCED AND CONSUMED IN UNITED STATES IN 1916–1917

State.	Production.					
	1916.			1917.		
	Volume, 1000 Cu. Ft.	Value.	Average Price per 1000.	Volume, 1000 Cu. Ft.	Value.	Average Price per 1000.
West Virginia	299,318,907	$47,603,396	15.90	308,617,101	$57,389,161	18.60
Oklahoma	123,517,358	12,014,706	9.73	137,384,154	13,984,656	10.18
Pennsylvania	130,483,705	24,513,119	18.78	133,397,206	28,716,492	21.53
Ohio	69,888,070	15,601,144	22.32	68,917,231	18,434,814	26.75
California	31,643,266	5,440,277	17.19	49,427,331	6,816,524	13.79
Louisiana	32,080,975	2,660,445	8.29	31,286,476	3,262,987	10.43
Kansas	31,710,438	4,855,389	15.31	24,438,848	5,701,436	23.33
Texas	15,809,579	3,143,871	19.89	17,047,292	3,192,625	18.73
New York	8,035,632	2,355,320	29.31	8,371,747	2,499,303	29.85
Arkansas	2,387,935	210,964	8.83	5,609,484	315,612	5.63
Illinois	3,533,701	396,357	11.22	4,439,016	479,072	10.79
Kentucky	2,106,542	752,635	35.73	2,802,079	580,380	20.71
Indiana	1,715,499	503,373	29.34	1,711,454	453,310	26.49
Wyoming, Colorado	575,044	86,077	14.97	1,223,136	144,425	11.81
Montana	213,315	38,855	18.21	334,421	81,406	24.34
South Dakota, Alabama, North Dakota	77,478	31,573	40.75	59,666	25,213	42.26
Missouri	69,236	17,594	25.41	31,425	8,230	26.19
Tennessee	2,000	1,150	57.50	10,900	2,450	22.48
Michigan	1,298	948	73.04	1,184	1,013	85.55
Iowa	275	275	100.00	225	225	100.00
Totals	753,170,253	$120,227,468	15.96	795,110,376	$142,089,334	17.87

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State.	Consumption.					
	1916.			1917.		
	Volume, 1000 Cu. Ft.	Value.	Average Price per 1000.	Volume, 1000 Cu. Ft.	Value.	Average Price per 1000.
West Virginia	105,104,008	$8,610,084	8.19	*115,488,192	$10,558,612	9.14
Oklahoma	†93,704,221	7,062,142	7.54	†122,177,676	10,900,827	8.92
Pennsylvania	201,460,893	35,015,695	17.38	202,259,498	40,773,689	20.16
Ohio	169,480,011	37,394,410	22.06	165,782,369	44,742,782	26.99
California	31,643,266	5,440,277	17.19	49,427,331	6,816,524	13.79
Louisiana	‡32,080,975	2,660,445	8.29	‡31,286,476	3,262,987	10.43
Kansas	¶60,564,112	9,731,518	16.07	¶37,962,857	8,463,767	22.29
Texas	15,809,579	3,143,871	19.89	17,901,637	3,433,123	19.18
New York	20,594,123	6,230,826	30.26	22,466,848	6,912,540	30.77
Arkansas	**3,347,398	287,399	8.59	**6,437,608	396,612	6.16
Illinois	§3,533,701	396,357	11.22	§4,439,016	479,072	10.79
Kentucky	9,887,956	2,331,687	23.58	12,053,445	3,114,402	25.84
Indiana	5,021,364	1,746,285	34.78	5,766,466	1,971,435	34.19
Wyoming, Colorado	575,044	86,077	14.97	1,223,136	114,425	11.81
Montana	213,315	38,855	18.21	334,421	81,406	24.34
South Dakota, Alabama, North Dakota	77,478	31,573	40.75	59,666	25,213	42.26
Missouri	69,236	17,594	25.41	31,425	8,230	26.19
Tennessee	2,000	1,150	57.50	10,900	2,450	422.48
Michigan	1,298	948	73.04	1,184	1,013	85.55
Iowa	275	275	100.00	225	225	100.00
Totals	753,170,253	$120,227,468	15.96	795,110,376	$142,089,334	17.87

* Includes gas piped from West Virginia and consumed in Maryland. † Includes gas piped from Oklahoma and consumed in Missouri. ‡ Includes gas piped from Louisiana and consumed in Arkansas and Texas. ¶ Includes gas piped from Kansas and consumed in Missouri. § Includes gas piped from Illinois and consumed in Indiana. ** Includes gas piped from Oklahoma.

With no aid from other statistical sources, the compilation of the data is naturally slow, and no estimate of the production for 1918 has yet been given out by the Government.

Both the Geological Survey and the Bureau of Mines have labored arduously during the past year to aid in the conservation of natural gas, and it is this effort which is most promising in retarding the inevitable decline of this industry.

Petroleum and Natural Gas in Foreign Countries

North America

Canada.—Ontario showed a slight increase in 1918, due to the shallow Mosa field, in Middlesex County, and the Trenton development in Dover Township, in Kent County. Between 12,000 and 15,000 bbl. were produced in the Calgary district of Alberta, where some drilling has persisted in spite of the difficulty of securing drilling materials. The three refineries in the Calgary field increased their output greatly, making 331,098 gal. of gasoline and 107,320 gal. of kerosene.

A new natural-gas field, assuring a further supply of natural gas for

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this district, has been discovered about 30 miles east of the city of Lethbridge, and about 4 miles north of Bamwell Station. The exact depth at which the gas was struck has not been divulged, but the Canadian Western Natural Gas, Light, Heat, and Power Co. states that the new well would be cut in at once on the main line running from the Bow Island field, and supplying Lethbridge, Calgary, and other cities along the line. While the new well is now producing 4,000,000 cu. ft. daily, there will not be this much added to the present gas supply, because the pressure in the main line is such that only about 1,000,000 cu. ft. daily of the 4,000,000 available from the new well will enter the line. The importance of the new strike, however, is the discovery of an entirely new gas field, separate and apart from the Bow Island field. So important is the find regarded by the company that plans are being made for a big program of development in the new field, and four or five more wells may be sunk next summer.

Much attention has been called in recent years to the oil shales in New Brunswick, but the *Canadian Chemical Journal* of March, 1919, now very sensibly calls attention to the fact that the shale deposits of Ontario were distilled for oil as early as 1859, record of which was made in a geological report of Canada for 1863. Considering that report in the light of present shale developments, the possibility of the utilization of these shales seems good.

Mexico.—In spite of insufficient transportation, and of irksome laws and federal regulation, production increased by 10,015,083 bbl., 64,605,422 bbl. being produced in 1918. Such wells as were drilled were of great size.

WELLS DRILLED IN 1918 IN MEXICO

Field.	Completed.	New Production.	Dry.	Salt Water.
South Fields	19	534,000	5	2
Panuco	18	82,450	4	3
Topila	2	30,000	..	1
Tamaulipas	2	.....	2	..
San Luis	1	.....	1	..
Totals	42	646,450	12	6

The completions listed above result in the following corrections to Mexico's table of producing wells, and dry, salt water and abandoned holes. The table follows:—

Field.	Number of Wells.	In Production.	Potential Production.	Dry, Salt Water, Abandoned.
(a) South Fields	201	62	913,438	139
Panuco	143	88	437,305	55
Topila	62	27	76,860	35
Miscellaneous	43	7	1,042	36
(b) Ebano	33	16	6,000	17
Tamaulipas	10	..	.....	19
San Luis	10	2	30	8
Isthmus	221	75	590	146
Totals	732	277	1,435,265	455

(a) Includes Furbero. (b) Approximated.

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The following is a detailed list of the wells completed in 1918:

South Fields	
Chinampa, Mexican Eagle, lot 163	50,000
Tepetate, Mexican Eagle, lot 4	Abandoned
[1] Casiano, Huasteca Petroleum Co., 8	Salt water
Chinampa, Huasteca Petroleum Co., lot 151	Dry
Chinampa, Huasteca Petroleum Co., lot 157	Dry
Alamo, Penn-Mex. Fuel, 8	Salt water
Amatian, International Petroleum Co., lot 252	25,000
Amatian, International Petroleum Co., lot 251(2)	25,000
Chinampa, Transcontinental Petroleum Co., lot 163	60,000
Tepetate, Texas Co., lot 11	50,000
Tepetate, Texas Co., lot 11	4,000
Chinampa, Texas Co., lot 153	25,000
Tepetate, Cortes Oil Corp., lot 5	50,000
Tepetate, Mexican Gulf Oil, lot 8	60,000
Chinampa, Mexican Gulf Oil, lot 148	Dry
Amatian, Cia. Pet. Tepetate, lot 251	75,000
Chioncillo, Cia. Pet. Tepetate, lot 2	35,000
Chinampa, Island Oil and Transportation Co., lot 162	75,000
Tepetate, Island Oil and Transportation Co., lot 8	Dry
Wells completed	19
New production	534,000
Salt water	2
Dry and abandoned	5

[1] Big oil show followed by water.

Panuco	
Barbarena, Transcontinental Petroleum Co., 2	50,000
Barbarena, Transcontinental Petroleum Co., 3	250
Barbarena, Transcontinental Petroleum Co., 4	5,000
Willis, East Coast Oil, 13	Dry
Halson, East Coast Oil, 1	1,000
Camolote, Mexican-Sinclair, lot 6	8,000
Riviera, English Oil Co., 1	4,000
Isleta, Texas Co., lot 17	Dry
Crus, New England Fuel, 1	4,000
Alamo, Southern Oil Co., 1	5,000
Medina, Eureka-Chautemoc, 1	1,800
Island, Petroleum La Maritima, 1	Salt Water
Magaubes, Petroleum La Oaxaquena, 1	Dry
Isleta, La Meridional, lot 6	2,000
Guzman, Esfuersa Nacional, 1	Salt water
Isleta, Punta Arena y Annexes, 1	Salt water
Mediana, La Commercial, 1	Dry
Tampuche, Panuco-Tuxpam, 1	1,400
Wells completed	18
New production	82,450
Salt Water	3
Dry	4

Topila	
Tamboyoche, Mexican Fuel, 3	30,000
Tamboyoche, Comercio de Pueblo, lot 12	Salt water
Wells completed	2
New Production	30,000
Salt water	1

Tamaulipas	
Soto la Marian district:	
San Jose, La Corona Petroleum Co., 4	Dry
San Jose, La Corona Petroleum Co., 5	Dry
Wells completed	2
Dry holes	2

San Luis Potosi	
Husalte, Mexican Eagle, 1	Dry
Wells completed	1
Dry holes	1

It is important to note the passing of the great Potrero del Llano No. 4 from oil to salt water. It was significant that this well, like the great Dos Bocos gusher, changed from oil to an emulsion of half salt water without any great change in the total yield of the well. Fairly considered, it is this menace of quick change from oil to water that gives instability to the Mexican outlook. It is far easier to calculate what to expect from

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WORLD'S MARKETED PRODUCTION OF CRUDE PETROLEUM, 1857–

Year.	Roumania.	U. S. A.	Italy.	Canada.	Russia.	Galicia.	Japan.[1]	Germany.
1857	1,977	.....	.....	.....	.....	.....	.....	.....
1858	3,500	.....	.....	.....	.....	.....	.....	.....
1859	4,349	2,000	.....	.....	.....	.....	.....	.....
1860	8,542	500,000	36	.....	.....	.....	.....	.....
1861	17,279	2,113,009	29	.....	.....	.....	.....	.....
1862	23,198	3,056,690	29	11,755	.....	.....	.....	.....
1863	27,943	2,611,309	58	82,814	40,816	.....	.....	.....
1864	33,013	2,116,109	72	90,000	64,586	.....	.....	.....
1865	39,017	2,497,700	2,265	110,000	66,542	.....	.....	.....
1866	42,534	3,597,700	992	175,000	83,052	.....	.....	.....
1867	50,838	3,347,300	791	190,000	119,917	.....	.....	.....
1868	55,369	3,646,117	367	200,000	88,327	.....	.....	.....
1869	58,533	4,215,000	144	220,000	202,308	.....	.....	.....
1870	83,765	5,260,745	86	250,000	204,618	.....	.....	.....
1871	90,030	5,205,234	273	269,397	165,129	.....	.....	.....
1872	91,251	6,293,194	331	308,100	184,391	.....	.....	.....
1873	104,036	9,893,786	467	365,052	474,379	.....	.....	.....
1874	103,177	10,926,945	604	168,807	583,751	149,837	.....	.....
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	.....
1876	111,314	9,132,669	2,891	312,000	1,302,528	164,157	7,708	.....
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	.....
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	.....
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	.....
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497	9,310
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	29,219
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	58,025
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473	26,708
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	46,161
1885	193,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237	41,360
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	73,864
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	74,284
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	84,782
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	68,217
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420	108,296
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,929
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	101,404
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384	99,390
1894	507,255	49,344,516	20,552	829,104	36,375,428	940,146	171,744	122,564
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	121,277
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,082	145,061
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	165,745
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	183,427
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	192,232
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	358,297
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	313,630
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,038	353,674
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371	445,818
1904	3,599,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473	637,431
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804	560,963
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	578,610
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838	756,631
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	1,009,278
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,018,837
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,032,522
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,017,045
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,031,050
1913	13,554,768	248,446,230	47,256	228,080	62,834,356	7,818,130	1,942,009	(a)995,764
1914	12,826,579	265,762,535	39,849	214,805	67,020,522	(a)5,033,350	2,738,378	(a)995,764
1915	12,029,913	281,104,104	43,898	215,462	68,548,062	4,158,899	3,118,564	(a)995,764
1916	10,298,208	300,767,158	50,652	198,123	72,801,110	6,461,706	2,997,178	(a)995,764
1917	(a)2,681,870	335,315,303	50,334	205,332	(a)69,000,000	5,965,447	2,898,654	1,000,000
1918	.....	350,131,000	.....	253,951	.....	.....	.....	.....
Total	142,992,465	4,602,775,000	941,022	24,366,480	1,832,583,017	148,459,653	36,065,454	15,957,097

[1] and Formosa. (a) Estimated.

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1918 BY YEARS AND BY COUNTRIES, IN BARRELS OF 42 GAL.

India.	Dutch E. Ind.	Peru.	Mexico.	Trinidad.	Egypt.	All Other.	Total.	Year.
.....	.....	.....	.....	.....	.....	.....	.....	1857
.....	.....	.....	.....	.....	.....	.....	.....	1858
.....	.....	.....	.....	.....	.....	.....	6,349	1859
.....	.....	.....	.....	.....	.....	.....	508,578	1860
.....	.....	.....	.....	.....	.....	.....	2,130,917	1861
.....	.....	.....	.....	.....	.....	.....	3,091,692	1862
.....	.....	.....	.....	.....	.....	.....	2,762,940	1863
.....	.....	.....	.....	.....	.....	.....	2,303,780	1864
.....	.....	.....	.....	.....	.....	.....	3,715,524	1865
.....	.....	.....	.....	.....	.....	.....	3,899,278	1866
.....	.....	.....	.....	.....	.....	.....	3,708,846	1867
.....	.....	.....	.....	.....	.....	.....	3,990,180	1868
.....	.....	.....	.....	.....	.....	.....	4,695,985	1869
.....	.....	.....	.....	.....	.....	.....	5,799,214	1870
.....	.....	.....	.....	.....	.....	.....	5,730,063	1871
.....	.....	.....	.....	.....	.....	.....	6,877,267	1872
.....	.....	.....	.....	.....	.....	.....	10,837,720	1873
.....	.....	.....	.....	.....	.....	.....	11,933,121	1874
.....	.....	.....	.....	.....	.....	.....	9,977,348	1875
.....	.....	.....	.....	.....	.....	.....	11,051,267	1876
.....	.....	.....	.....	.....	.....	.....	15,753,938	1877
.....	.....	.....	.....	.....	.....	.....	18,416,761	1878
.....	.....	.....	.....	.....	.....	.....	23,601,405	1879
.....	.....	.....	.....	.....	.....	.....	30,017,606	1880
.....	.....	.....	.....	.....	.....	.....	31,992,797	1881
.....	.....	.....	.....	.....	.....	.....	35,704,288	1882
.....	.....	.....	.....	.....	.....	.....	30,255,479	1883
.....	.....	.....	.....	.....	.....	.....	35,968,741	1884
.....	.....	.....	.....	.....	.....	.....	36,764,730	1885
.....	.....	.....	.....	.....	.....	.....	47,243,154	1886
.....	.....	.....	.....	.....	.....	.....	47,807,083	1887
.....	.....	.....	.....	.....	.....	.....	52,164,597	1888
94,250	.....	.....	.....	.....	.....	.....	61,507,095	1889
118,065	.....	.....	.....	.....	.....	.....	76,632,838	1890
190,131	.....	.....	.....	.....	.....	.....	91,100,347	1891
242,284	.....	.....	.....	.....	.....	.....	88,739,219	1892
298,969	600,000	.....	.....	.....	.....	.....	92,038,127	1893
327,218	688,170	.....	.....	.....	.....	.....	89,335,697	1894
371,536	1,215,757	.....	.....	.....	.....	.....	103,562,510	1895
429,979	1,427,132	47,536	.....	.....	.....	.....	114,159,183	1896
545,704	2,551,649	70,831	.....	.....	.....	.....	121,948,575	1897
542,110	2,964,035	70,905	.....	.....	.....	.....	124,924,682	1898
940,971	1,795,961	89,166	.....	.....	.....	.....	131,143,742	1899
1,078,264	2,253,355	274,800	.....	.....	.....	(a)	149,132,116	1900
1,430,716	4,013,710	274,800	.....	.....	.....	20,000	167,424,089	1901
1,617,363	2,430,465	286,725	.....	.....	.....	26,000	181,965,876	1902
2,510,259	5,770,056	278,092	.....	.....	.....	36,000	194,804,294	1903
3,385,468	6,508,485	345,834	220,653	.....	.....	40,000	218,299,419	1904
4,137,098	7,849,896	447,880	320,379	.....	.....	30,000	215,361,296	1905
4,015,803	8,180,657	536,294	1,097,264	.....	.....	30,000	214,010,124	1906
4,344,162	9,982,597	756,226	1,717,690	.....	.....	30,000	264,958,008	1907
5,047,038	10,283,357	1,011,180	3,481,610	169	.....	41,000	285,089,984	1908
6,676,517	11,041,852	1,316,118	2,488,742	57,143	.....	38,000	298,373,216	1909
6,137,990	11,030,620	1,330,105	3,332,807	142,857	.....	40,700	327,615,603	1910
6,451,203	12,172,949	1,368,274	14,051,643	285,307	9,150	33,000	345,685,081	1911
7,116,672	10,845,624	1,751,143	16,558,215	436,805	205,905	67,000	352,484,591	1912
7,930,149	11,966,857	2,133,261	25,902,439	503,616	94,635	150,600	384,667,550	1913
6,190,476	(b)12,705,208	1,917,802	21,188,427	643,533	777,038	295,000	399,264,168	1914
6,833,333	(b)12,386,808	2,487,251	32,910,508	(a)750,000	262,208	526,000	426,370,894	1915
7,076,161	(b)13,174,399	2,489,458	39,817,402	928,581	411,000	820,000	459,433,319	1916
6,732,370	(b)12,928,955	2,533,417	55,292,770	1,599,455	1,008,750	8,149,710	505,362,367	1917
.....	.....	.....	64,605,422	.....	2,113,900	.....	.....	1918
94,149,747	175,103,267	21,878,285	286,687,894	5,347,466	4,882,586	10,373,010	6,988,479,090	bbl.

(b) Includes British Borneo. (c) Includes 600,000 bbl. produced in Argentina.

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a region in which the wells show the normal decline consistent with a given thickness of oil sand, as in Pennsylvania or Oklahoma, but in Mexico a conservative concern can only be assured of continued production by controlling oil tracts well separated from each other. Thus far, a change of oil to salt water in an individual well cannot be said to have resulted in injury to any large territory, but the extent to which water encroachment is already following the decline of large wells can only be told by further drilling, and the precedent of other countries in wells of this Mexican type is none too favorable for very long life.

Great growth of oil storage and refining capacity is noted in the Tampico region.

Trinidad.—This island remains the chief source of petroleum, as well as asphalt, for the western hemisphere, outside of the United States and Mexico. According to the reports of Consul Henry D. Baker, of Trinidad, S. Pearson & Sons, of London, has sent five geologists to Trinidad to explore about 200,000 acres of oil concession, with the prospect of beginning operations on their usual large scale if favorable report is received.

Thicknesses of 6000 ft. or more of Tertiary sandstones are frequently oil-bearing. Four principal anticlines have been recognized, which extend in a generally east and west direction across the southern part of the island. The known oil area is constantly being added to. The producing companies are hoping for the removal of war restrictions, so that they may get casing, which is essential with the fine soft formations encountered.

In 1918 the exports of crude oil from Trinidad reached 1,000,000 bbl., against 800,000 bbl. in 1917, and in January shipments reached 160,000 bbl.; these figures are based on contracts with the British Admiralty. More and more ships are calling at Trinidad for bunker oil.

The four leading companies operating in Trinidad are the Trinidad Lake Petroleum Co., the United British Petroleum Co., the Trinidad Leaseholds Co., Ltd., and the Trinidad Central Oil Fields, Ltd., all having headquarters in London, England.

South America

Venezuela.—With the return of peace conditions, this country, with an area of 393,976 sq. mi., and 3,000,000 population, will become an important oil producer. Oil seeps are frequent and large over widely separated areas, and in spite of most unfavorable conditions, the production stage has been reached at Lake Maracaibo by an American concern, the Caribbean Petroleum Co.; and at Perida, west of Lake Mara-

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caibo, and at Mene Cande, on the east side of the lake, five other companies are in the field. In 1917, 18,249 tons of crude was produced and about 25,000 tons in 1918. Further, a refinery is operated on a small scale at San Lorenzo, 50 miles south of Maracaibo. Most of the crude oil goes, however, to the refinery at Curacao. Steamers, railways and some stationary plants have begun to use oil fuel. The future demand for oil products is shown by the imports, which still exceed a total of $600,000 in value.

The Venezuelan Oil Concessions, Ltd., and English company operating in Venezuela, has secured from the Colonial Office a concession in the northwest district of British Guiana to explore for oil.

Colombia.—According to Consul John A. Dunn, a Pennsylvania corporation has been engaged in prospecting the territory covered by an important concession in the interior of Colombia in what appear to be oil-bearing lands during the past two years, and early in April of this year brought in a well that gives promise of being a good producer, tapping the oil-bearing strata at about 1500 ft. Oil-bearing sands were also passed through at 500- and 1200-ft. depths. This well, unfinished as it stands, is said to be good for from 1000 to 1200 bbl. per day of light, asphalt-base oil.

This company is operating on the Colorado River, about 35 miles east of the Magdalena River at Barranca Bermeja, or about 420 miles from the mouth of the Magdalena. The company has also a second well drilling and it has reached a depth of about 740 ft. and is reported to be in a very promising formation.

Several efforts have been made at various times to develop oil in Colombia in commercial quantities, but without previous success. Various wells have been drilled near Puerto Colombia by a Canadian and, later, an American company; south of Barranquilla by a California promoter; and in the valley of the Sinu River by an American company; but none have proven producers. A New York company is now drilling near Mariquita, along the La Dorada Extension Railway, 200 miles to the south of the Tropical Oil Co.'s workings. Various other American companies have done superficial exploration work in Colombia and some have secured extensive optional leases on lands supposed to be oil bearing, but only those mentioned have done any active mechanical work.

After the termination of the war it is expected the oil fields of Colombia will meet with considerable development at the hands of American and other foreign interests.

Argentine.—While there was little change in production in the Comodoro Rivadavia field, much more attention was devoted to the exploration of the high-grade oils shown by seepages over large areas in northern

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Argentine and southern Bolivia. These are described by Stanley C. Herold in the *Transactions of the American Institute of Mining Engineers* for 1919.

EUROPE

Great Britain.—S. Pearson & Sons (the Cowdray interests) received a commission from the British Government to undertake exploration for oil in Derbyshire, England. In starting this work, ten drilling outfits were obtained from the United States, and the following seven boring sites on the east side of Chesterfield were located, in a north and south line 19 miles in length, as follows: (1) Ridgeway, (2) Foxstones, (3) Brimington, (4) Heath, (5) Hardstoft, (6) South Normanton, (7) Golden Valley. At the end of November No. 5 was down about 500 ft., and was being sunk at the rate of 20 ft. per day. No. 3 had the derrick about complete, and the other buildings about three parts completed. No. 2 had some plant on the ground; while the others had either little or no plant as yet. It was expected that the first well at No. 5 location would be down the intended depth during May; in fact, oil was obtained.

In May, 1919, drilling at the location known as Hardstoft No. 1 had reached a depth of approximately 3000 ft. At this depth, oil of good quality was obtained, which rose to a height variously estimated at from 50 to 450 ft. in the well. It is understood that the oil-bearing sand was found at about the horizon forecasted by Mr. A. C. Veatch and others of Lord Cowdray's staff, who are to be credited with this new British oil development under the extremely progressive policy of Lord Cowdray in thus contributing to great British wealth.

While little can be said as to the probable quantity which may be expected, the results are sufficiently encouraging to insure thorough development of the field. The oil is described as being of good quality, with a liberal amount of gasoline and paraffin wax.

Scotch Shale Industry.—The Scotch mineral oil companies have taken steps for a central sales agency for effecting greater economy. This includes the Broxburn Oil Co., the Oakbank Oil Co., the Pumpherston Oil Co., James Ross & Co., and Young's Paraffin Light and Mineral Oil Co. This agency acts as a private company, with limited liability, and will sell and distribute all the products of the companies mentioned.

Hungary.—The utilization of natural gas in Hungary will probably reduce the consumption of coal very greatly before the next few years. The total amount of natural gas in the Siebenburgen region has been estimated at 60,000,000,000 thousand feet. This is in addition to the considerable supplies of natural gas located in other localities in Hungary.

The Siebenburgen field has been exploited by the drilling of some 52

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wells, and the pressure has not been seriously reduced, even after the extraction of over one billion cubic feet. The cost of production is low.

Italy.—The only petroleum produced in Italy comes from wells at Gropperello and Lugagnano Val d'Arda, and from those near Vernasca and Rivergaro in the province of Piaceuza. The output has declined from 10,000 tons in 1911 to 6000 in 1917, although exploration has been active. Gas wells in the provinces of Piacenza and Parma yield from 180,000,000 to 210,000,000 cu. ft. per year.

Roumania.—The Roumanian oil fields, so efficiently wrecked by the Allies when withdrawing from that region, were repaired as rapidly as possible by the German army, and the energetic work of the Roumanian Government in leasing the Crown petroleum lands is rapidly bringing the production back to that of the pre-war condition.

The production for 1918 can be estimated at 5,000,000 barrels. The advance in Roumanian production, and especially in Roumanian refining, will be rapid as soon as compensation for damage caused by the war shall have been settled, and the money made available for development purposes. Practically all of the companies which were dispossessed during the German occupation have obtained possession of their rights, and have entered into work again.

The largest oil company in Roumania was owned in Berlin, and it is reported that the liquidation of all German property has been ordered.

Russia.—The condition of revolution in Russia reduced the production of petroleum very greatly, except in the Naku district, which continued actively under British protection. According to the correspondent of the *Petroleum Times*, of London, production in the Baku fields for 1918 was as follows:

	Poods.
January	28,573,739
February	22,745,368
March	20,000,000
April	17,700,000
May (18 days)	10,918,041
June	17,564,684
July	17,225,915
August	11,207,224
September	5,666,816
October	9,529,413
November	11,683,727
December	12,377,067
Total	185,192,794

N.B. 61.05 poods = 1 metric ton crude; 8.33 poods crude = 1 United States barrel of 42 gallons.

The above figures do not include the hand-dug wells, which yielded about 1,000,000 poods per month, making 200 million poods in round numbers for the total production of the Apsheron Peninsula during 1918.

No estimate is available for the other Russian oil districts, but the production was very small.

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On account of the impossibility of exporting any great amount of oil to foreign countries, stocks in Baku accumulated very greatly, and included one million tons of crude oil, 128,000 tons of lamp oil, 16,000 tons of gasoline and 48,000 tons of various kinds of lubricating oils. The high price of drilling requisites and of labor have made drilling almost impossible.

Spain.—This country imports over $3,500,000 worth of petroleum oils and paraffin wax, chiefly from the United States, and during the last year imports in general from the United States have increased.

There are many indications of petroleum in Spain, and in Aragon, Navarre Teruel, Alicante, Castellon and Malaga, oil shales have been found. In Levante and Vizcaya shale retorts have been installed.

Asia

Persia.—According to *Commerce Reports*, continued progress is being made by the Anglo-Persian Oil Co., which has contracts for over 12,000,000 tons of fuel oil and other products. The Government of India has decided, after experiments, to use oil in place of coal on the western division of its railroad. The oil can be sent from the Persian Gulf to the west coast of India in 15 days, against 30 days for coal from Bengal. The Mesopotamian railroads are likely to take similar action.

The Anglo-Persian Co. has absorbed the shares of the British Petroleum Co., the Homelight Oil Co., and the Petroleum Steamship Co., distributing companies. About 150,000 tons of gasoline are now produced, but extensions are designed to bring this to 600,000 tons. The present obtainable crude oil is supposed to exceed that of the entire Roumanian and Galician oil fields before the war. The crude yields a large percentage of gasoline. Of the capital (£6,000,000) the British Government owns £2,200,000. The company owns 22 oil-carrying vessels and manages 9 more.

British India.—The report of the British Burmah Co. for 1918 shows an increase to 502,400 bbl. from 442,000 bbl. in 1917, in spite of many difficulties in obtaining drilling supplies. The Rangoon Oil Co.'s production was about the same as in 1917. In general the Yenangyamng region is declining, although very favorable results have been obtained in the Beme section.

Japan.—While the very latest advices from Japan indicate that crude oil production has considerably improved during the first months of 1919, the year 1918 did not show very favorably. In all, the production in Japan decreased about 25 per cent. for the year 1918, as compared with 1917, the production in 1917 having been estimated as 1,600,000 koku (1 koku = 1.135 U. S. bbl.).

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Good strikes of oil have lately been made in the Nishiyama field, where three wells came in with unexpectedly good results. Wells that produce from 100 to 250 barrels per day as initial production are considered very satisfactory. In the Toyokawa field, the Hoden Oil Company has obtained some wells with 500 barrels initial capacity. In the Niitsu field, the Kuhara Mining Company has begun drilling, and the Takata Company, in the same district, have already obtained five producing wells. It cannot be expected that these additions to the oil resources of Japan can in any way make up for the steady decline in the older fields.

Africa

Egypt (By R. H. Graves).—During 1918 the output of petroleum in Egypt was doubled, the total being 281,885 metric tons as compared with 136,845 metric tons in 1917.

The production for the past eight years is as follows:

	Metric Tons.
1911	2,793
1912	27,962
1913	12,786
1914	99,680
1915	30,054
1916	57,743
1917	136,845
1918	281,885

From 1911 to 1914 the bulk of the output came from the Gemsah field; since 1915 the majority has been produced by the Hurghada field. The refinery at Suez has a capacity of 1000 tons per day.

Prospecting has been practically at a standstill owing to the difficulty of obtaining oil-well supplies, which all have to be imported; it is anticipated, however, that as conditions become more normal active exploration will gradually increase. The Egyptian Government has maintained its geological investigations of structures and mapping of likely oil areas, which are extensive on both sides of the Gulf of Suez.

Australasia

New Zealand.—In 1918 the local Government began paying a bounty for the production of the first petroleum in New Zealand, and future development will be encouraged. On the west coast of South Island valuable oil shales are noted, which the Government will help to develop.

Oil Shales

The condition of the oil-shale industry during 1918 was one of increasing interest, evinced by the location of practically all the available shale

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lands known on the public domain by all sorts of concerns, from individual claimants to large corporate interests. Interest was also shown by the larger oil companies, most of whom have sent experts to carefully examine and report on the shales of Colorado, Utah, western Wyoming, Nevada and California, and especially to familiarize themselves with the pioneer efforts at shale development in Nevada and California, in order that they may quickly reap the fruit of the work of others at the right time. Many of these large corporations have professed the belief that oil-shale development will only be a feature some 10 years hence; but it does not appear that such belief has deterred them from acquiring good shale holdings at the present time. About the end of the year, a more immediate interest has come to be manifested, due, apparently, to certain misgivings as to the prospects of controlling Mexican oil, suggested perhaps by the change of ownership of a large block of stock of Mexican Eagle (Cowdray interest) over to the Dutch Shell interest. The actual acquisition of large holdings in California by British interests, against which vigorous protests have been made, has turned attention to shale oil. Again, the decline in production in 1918 in the great Oklahoma fields was nearly as great as the total product of the wonderful North Central Texas field, and greater than the increase in that region. This new Texas region is most reassuring when considering the general decline outside of the south. It gave great impetus to oil exploration over new portions of Texas. Nevertheless, the conservative element of the oil industry is not inclined to risk a future adequate supply to chance oil-field discoveries when the outlook is getting better for oil from shale in satisfactory quantity and at a reasonable cost.

As to actual experimentation in oil-shale retorting, the year records some actual progress. At Elko, Nev., Mr. Robert M. Catlin, who has owned a vein of rich shale for many years, erected a screw-conveyor furnace, and produced some 2000 gal. of crude oil. Since this he has been erecting a larger furnace, the type of which has not been disclosed, which was to be put in operation in May, 1919, with a capacity of 100 tons per 24 hours.

In the same region, near Elko, Nev., the Southern Pacific Co. began a coöperative development with the Federal Bureau of Mines, erecting a full-sized unit of the Pumpherston Scotch retorting system. The furnace is 55 ft. high by 18 ft. wide at the base, and contains four vertical retorts. The lower 15 ft. of these retorts is fire brick specially made by the Denver Fire Clay Co. from plans obtained by David T. Day from Sir James Bryson, the designer of the Pumpherston system—the system according to which practically all new Scotch retorts are now being built, as fast as the older types of furnaces are worn out. In the upper 15 ft.

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is a cast-iron cylinder, surmounted by a hopper holding 10 tons or more of shale. The shale will be crushed to 3 in. in diameter by Allis-Chalmers spiked-toothed rolls capable of crushing 500 tons per 24 hours. The shale is then stored in bins from which it is delivered to the retorts by a belt conveyor. An adequate electric power system pumps water from a well in the Humboldt River flat, through a 2-in. line to a tank on a hill above the furnace, from which the water flows to all parts of the plant. The water line is so well buried that it escaped freezing during the severe winter weather. The electric plant also operates the crusher, conveyor and shale extraction mechanism and furnishes light. The shale is furnished from Government property, on the adjoining section, and from various lands of the Southern Pacific Co. Further tests of shale from various other localities will be made in 50-ton lots—that amount being required to fill the furnace. The capacity of the furnace as run in Scotland is 24 tons per 24 hr., when run for the maximum ammonia yield as well as oil.

In California, an experimental furnace was erected during the latter half of 1918, by Mr. Verner Z. Reed, of Denver, Colorado, to utilize a bed of oil-soaked Monterey shale at Shuman Cut, near Casmalia, in Santa Barbara County, about 90 miles north of Santa Barbara. The furnace is of the horizontal screw-conveyor type, with certain innovations which have not been published. Experiments began in the furnace late in November, and were continued until the death of Mr. Reed, in April, 1919, when the furnace was taken over by other interests. The results thus far obtained have not been published, but it is known that complete extraction of the oil was effected and that the product proved unexpectedly rich in gasoline.

At the end of the year the Ute Oil Co., owning rich oil shales on White River, Uintah County, Utah, had contracted for a plant of 150 tons a day, of the Wallace system, and part had been delivered on the ground. This is a system of vertical retorts, containing a vertical tube pierced with small holes through which the oil vapors pass from shale filling the annular space between the outer retort and the perforated inner tube. When the shale is exhausted, the retort is emptied and refilled. The engineering features are well worked out; and the plant should be in operation in October, 1919.

It is not known that any other of the various retorting schemes will be in operation during 1919, although the Jensen, Galloupe, Wingett and other ideas are being vigorously experimented with.

One of the most noteworthy articles on the subject of oil shales was published recently by Dr. Robert A. Chesebrough, in the *New York Sun*. In it Dr. Chesebrough emphatically claims the practicability of utilizing

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oil shales at the present, and coming from such an authority the conclusions are entitled to weight, for he began the distillation of such shales in Brooklyn in 1858. He also began the utilization of heavy fuel oils in place of coal.

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PHOSPHATE ROCK

By William H. Waggaman

The signing of the armistice came too late to stimulate appreciably the production of phosphate rock during 1918, but preparations were immediately begun by the operators in the United States to handle a greater export business in 1919 than ever before in the history of this industry. Owing to the war the figures showing the production of phosphate rock in foreign countries have been very incomplete for the last 4 years. There has been, however, a considerable decrease in the world production of phosphate since 1913, owing to the curtailment of exports, the scarcity of labor, and the consumption for other purposes of the sulphuric acid formerly used in the production of acid phosphate for fertilizer purposes. Since most of the annual output of phosphate from the African and insular deposits is consumed in other countries, the difficulties in exporting rock have had a very much more marked effect upon the production in foreign fields than in the United States, where the greater bulk of the phosphate is mined for domestic consumption.

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD (a)
(In metric tons)

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Algeria	332,897	388,515	461,030	(e)355,140	(e)225,891	(e)380,211	(e)202,539	(e)234,825
Augaur Palau Island.	41,000	50,000	90,000	(e)60,000	30,000	30,000	(c)	.....
Belgium	196,780	203,110	219,420	105,330	16,350	77,740	138,800	.....
Canada	506	149	349	866	197	184	135	127
Christmas Island (d).	250,000	300,000	(f)150,005	95,234	24,119	(c)	(c)	.....
Dutch W. Indies								
Aruba	88,430	17,215	.....	(e)86,572	.....	14,468	4,000	.....
Curacao	2,000	.....	1,850	(e)11,219	(e)32,915			
Egypt	6,425	69,958	101,311	71,945	82,998	125,008	115,732	31,147
France	312,204	330,000	335,000	270,000	.....	25,000	(c)	.....
French Guiana	.....	.....	.....	.....	.....	.....	(c)	.....
Makatea (d)	12,000	40,000	82,000	72,925	71,724	39,285	32,259	.....
Norway	.....	.....	757	750	.....	.....	.....	.....
Ocean Island	250,000	300,000	250,000	.....	.....	70,000	.....	.....
Russia	10,200	25,000	25,000	15,000	.....	.....	.....	.....
Spain	3,520	3,292	3,548	8,312	9,080	14,111	28,148	.....
New Zealand	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000	(b)10,000
Tunis	1,446,633	2,057,498	2,284,678	1,427,161	1,389,074	1,695,295	999,326	818,962
United States	3,260,626	3,216,046	3,068,604	2,752,971	1,873,625	2,177,292	2,652,776	2,530,861
Japan	2,271	7,849	19,047	38,252	57,723	114,389	121,609	.....

(a) Based on marketed output. (b) Estimated. (c) Statistics not available. (d) Figures furnished by Charles Michel, Paris. (e) Exports.

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The phosphate deposits of the world in the order of their present commercial importance are as follows: the phosphates of the United States including those of great value and extent in Florida, Tennessee, South Carolina, and the western States, Utah, Idaho, Wyoming, and Montana, and deposits of less importance in Kentucky, Arkansas, North Carolina and Virginia; the deposits of northern Africa in Tunis, Algeria and Egypt; the deposits of the Pacific and Indian Oceans, including those of Ocean, Christmas and Pleasant Islands, the Islands of the Marshall and Society groups, and New Zealand; the phosphates of Russia, the phosphates of Belgium and France; the Peruvian guano deposits; and the many smaller deposits in various other countries.

The world's output of phosphate rock for the past 8 years, as far as can be learned at present, is given in Table I.

United States

Ever since the discovery of phosphate rock in South Carolina in 1868 the United States has been the foremost phosphate-producing nation in the world. Although we have mined and marketed more than 40,000,000 tons of phosphate rock during the past decade, our known reserve supplies of this mineral are constantly being increased by fresh discoveries. The latest estimated amount of high-grade rock and its low-grade equivalent is placed at 10,500,000,000 tons. In 1918 the production of phosphate rock in this country amounted to 2,695,543 long tons as against 2,610,743 tons in 1917; thus in spite of the abnormal conditions resulting from the war, there was an increase of more than 500,000 tons in the production of this mineral over the previous year. There were, however, only 2,490,760 long tons marketed in 1918 as against 2,584,287 tons in 1917.

Most of the phosphate rock consumed in this country is manufactured into acid phosphate, but there is a constantly growing demand for finely ground raw rock phosphate to be applied directly to the field. The amount of this material consumed in 1918 was well over 130,000 tons, as against 90,321 tons in 1917. In addition to that consumed for fertilizer purposes, a considerable tonnage of phosphate rock was used in the manufacture of phosphorus. This element was employed during the war in the production of smoke screens and in incendiary bombs. The baking-powder industry also consumes a considerable quantity of phosphate rock, but no figures are available on the amount used for these purposes.

The production, exports and consumption of phosphate for the past 4 years in the United States are given in Tables II and III and the

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imports and exports of various fertilizer materials are shown in Tables IV and V.

TABLE II.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES
(In tons of 2240 lb.)

Phosphate.	1915.		1916.		1917.		1918.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida soft rock	.....	.....	.....	.....	.....	.....	17,736	$212,832
Florida hard rock	42,962	$231,995	81,071	$432,919	93,339	$457,881	42,840	310,590
Florida land pebble	1,368,282	4,186,943	1,601,061	4,739,141	2,016,462	5,242,801	2,141,950	5,997,460
Total, Florida	1,411,244	$4,418,938	1,682,132	$5,172,060	2,109,801	$5,700,682	2,202,526	$6,520,882
S. Car. land rock	78,543	$329,902	39,035	$147,552	45,541	$188,358	51,387	$231,242
S. Car. river rock	.....	.....	.....	.....	.....	.....	.....	.....
Total, S. Carolina	78,543	$329,902	39,035	$147,552	45,541	$188,358	51,387	$231,242
Tennessee	383,833	$1,063,217	454,515	$1,363,545	439,022	$1,819,307	430,288	$2,581,728
Other States	.....	.....	1,610	10,797	16,379	45,304	11,342	56,710
Total, U. S.	1,873,625	$5,812,057	2,177,292	$6,693,954	2,610,743	$7,753,651	2,695,543	$9,390,562

TABLE III.—STATISTICS OF PHOSPHATES IN THE UNITED STATES
(In tons of 2240 lb.)

Year.	Production.	Imports.	Exports. (a)	Consumption.
1909	2,463,766	11,903	1,020,556	1,455,113
1910	2,681,938	19,319	1,083,037	1,618,220
1911	3,216,993	16,153	1 246,577	1,980,569
1912	3,166,032	28,821	1,206,520	1,988,333
1913	3,062,975	26,408	1,366,508	1,724,525
1914	2,752,971	15,078	964,114	1,839,057
1915	1,873,625	5,359	253,421	1,625,435
1916	2,177,292	4,612	243,678	2,081,467
1917	2,610,743	*Nil.*	166,358	2,653,829
1918	2,695,543	*Nil.*	143,891	2,346,869

(a) Neglecting the insignificant exports of foreign products.

Florida.—While the production of Florida phosphate has largely recovered from the great depression noted in 1914, there has been a considerable curtailment in the output of phosphate rock from this State ever since the war, owing to the cutting off of most of the export trade. Florida, however, continues to hold first place as the greatest phosphate-producing area in the world.

In 1918 twenty companies were engaged in mining phosphate rock, which is the same number as were thus engaged in 1917. Many of the plants, however, were only running intermittently and few of them at full capacity. The total production in 1918 amounted to 2,202,526

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long tons as against 2,109,801 tons in 1917. Of this quantity 2,067,230 tons was marketed and only 143,891 tons was exported.

There was very little activity shown in the hard-rock regions of Florida during 1918. Since practically all of the high-grade rock is produced for the export trade, most of the plants have been practically closed down for the period of the war. Several concerns were, however, producing "soft phosphate," a clay-like phosphatic material, which is said to be quite effective as a fertilizer in its raw or untreated state. The total production of the hard-rock phosphate in 1918 amounted to 42,840 tons. There was, however, 57,771 tons exported as against 12,431 tons in 1917. The amount of soft phosphate produced for direct application to the field amounted to 17,736 tons, nearly all of which was consumed in this country. The average price of the hard rock was $7.25 per ton; the average price of the soft phosphate was $12.00 per ton.

The land-pebble phosphate industry has not suffered nearly so much on account of the war as the hard-rock industry, since most of the former product is manufactured into fertilizer which is consumed in this country. Moreover, the fact that the material can be more readily and cheaply mined affords it a better market than the higher grade but more costly hard rock. In 1918 eleven companies were engaged in mining pebble phosphate, which is the same number as were thus engaged in 1917. The production of Florida pebble phosphate in 1918 amounted to 2,141,950 tons, but only 1,996,847 tons was actually marketed. Of this amount 64,559 tons was exported. The remaining 1,932,288 tons, or nearly 97.0 per cent. of the entire output, was consumed in this country. The average price of the rock during 1918 was $2.80 per ton. The statistics of Florida phosphate are given in Table VI.

TABLE IV.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES
(In tons of 2240 lb.)

	1915.		1916.		1917.		1918.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ammonium sulphate	32,447	$1,934,625	12,962	$954,815	7,263	$649,125	2,993	$425,881
Phosphates (crude)	5,359	50,606	4,612	36,389	*Nil.*	.....	*Nil.*	.....
Apatite	*Nil.*	.....	*Nil.*	.....	*Nil.*	.....	1	30
Basic slag	76	1,343	71	759	*Nil.*	.....	.....	.....
Bone dust	21,322	540,197	18,124	487,857	10,519	308,497	5,183	154,231
Guano	9,974	220,860	12,997	378,109	6,500	140,101	8,206	280,544
Kainit	6,674	95,440	36	1,173	*Nil.*	.....	*Nil.*	.....
Manure salts, tons	13,947	207,674	1,104	21,273	190	8,872	*Nil.*	.....
Potash (muriate)	577,742	2,297,149	1,161	348,961	737	196,585	379	102,109
Potash (sulphate)	11,344	663,399	1,514	381,684	203	21,702	90	15,329
Nitrate of soda	772,190	22,959,997	1,218,423	38,131,962	1,555,839	60,283,900	1,845,192	90,379,285
All other fertilizers	.....	2,922,914	.....	3,223,724	.....	4,456,363	.....	4,018,013

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TABLE V.—EXPORTS OF FERTILIZER MATERIALS IN 1917 AND 1918
(In tons of 2240 lb.)

	1917.		1918.	
	Quantity.	Value.	Quantity.	Value.
Superphosphates	8,479	$528,103	7,041	$259,303
Sulphur or brimstone, crude			131,092	3,626,638
Phosphate rock, not acidulated:				
High-grade hard rock	12,431	113,531	57,771	445,419
Land pebble	137,610	547,278	64,559	303,758
All other	16,472	187,677	21,561	183,385
All other fertilizers	168,536	5,181,530	73,629	3,338,045

TABLE VI.—STATISTICS OF FLORIDA PHOSPHATE
(In long tons)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1911	474,094	2,020,477	2,494,571	2,456,440	1,290,779	1,165,661
1912	536,379	2,043,486	2,579,865	2,422,932	1,219,927	1,203,005
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450
1914	309,689	1,787,597	2,138,891	2,138,891	1,209,898	928,993
1915	42,962	1,368,282	1,411,244	1,411,244	1,158,052	253,192
1916	81,071	1,601,061	1,682,132	1,520,706	1,317,270	203,435
1917	93,339	2,016,462	2,109,801	2,096,670	1,963,524	133,146
1918	42,840	2,141,950	2,202,526[1]	2,067,230	1,944,894	122,336

[1] Includes 17,736 tons of soft phosphate sold for direct application to the field.

Tennessee.—Of the three classes of phosphate in Tennessee, namely the brown, blue, and white rock, only the first two have so far proved of much commercial importance. The brown rock, which is of Ordovician age, continues to be the most actively exploited. The more important localities where mining is now being conducted are in the vicinity of Mt. Pleasant, Maury County, near Centerville in Hickman County, and in the vicinity of Wales Station in Giles County. The rock ranges in grade from 55 to 78 per cent. bone phosphate of lime, depending on the locality. The average grade is about 72 per cent.

The blue or Devonian phosphate is being mined near Gordonsburg in Lewis County, and also in the Centerville region. The average grade of the blue rock is about 75 per cent. bone phosphate of lime. The average price of brown and blue phosphate rock in 1918 was $5.12 per ton.

While small deposits of white phosphate occur in rich pockets both in Perry and Decatur counties, these occurrences are so irregular that it has not proved profitable to mine them in competition with the more regular deposits of brown and blue rock. No production of white phosphate has been reported for a number of years.

In 1918 nine companies were engaged in mining Tennessee phosphate as against eight in 1917. The total production amounted to 430,288

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long tons as against 439,002 tons in 1917. Only 367,936 tons of Tennessee phosphate was actually marketed in 1918, practically all of which was consumed in this country.

South Carolina.—The nodular phosphates of South Carolina were the first important deposits of this mineral discovered in the United States and for a long time were the most eagerly exploited. They are, however, becoming of less commercial importance each year, since the expense of mining and the relatively low content of phosphoric acid in the rock as compared with the Florida and Tennessee phosphates has discouraged further development in these fields. Contrary to general opinion, however, the South Carolina phosphates are far from exhausted, and since much capital is invested in mining equipment these fields will, no doubt, continue to supply a fair annual tonnage to the fertilizer industry. The production in 1918 amounted to 51,387 tons, an increase of 5846 tons over the previous year, when 45,541 tons was produced. Only 37,040 tons was actually marketed in 1918. The average price of the rock for the year was $4.50 per ton.

Utah, Idaho, Wyoming and Montana.—The latest estimates of the amount of high-grade phosphate rock in these four states show a reserve supply of 5,750,000,000 tons. This tonnage will, no doubt, be increased by fresh discoveries as the survey of the phosphate areas is continued. An extension of these fields has recently been found in Canada. The rock, which is of Carboniferous age, occurs in beds from a few inches to 6 ft. or more in thickness, and has an average content of 70 per cent. bone phosphate of lime. Most of the phosphate occurs on Government land, and in order to conserve it large areas in the above states have been withdrawn from entry. Provision has been made, however, for the leasing of such lands on the payment of royalty to the Government. The outstanding withdrawals in these four states amounts to 2,605,065 acres. While a number of valuable phosphate deposits had already been taken up before the above withdrawals were made, the companies owning these properties have been mining only intermittently, since the distance of the fields from the fertilizer market and the high freight rates renders it commercially impracticable for these phosphates to compete at present with the eastern phosphates which are so much more favorably located in regard to the centers where most of the fertilizer is consumed. In 1918, 4743 tons was produced in the western fields, as compared with 16,379 tons in 1917.

Kentucky.—A number of deposits of high-grade phosphate rock have been found in the Ordovician limestone in Woodford, Scott, Fayette and Jassamine counties, Kentucky. The rock resembles the brown phosphate of Tennessee and is of a similar grade. Some development work

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has been conducted south of Midway, Ky., and several thousand tons produced and marketed. In 1918, the producton amounted to 6599 tons. The price of this rock averaged $6.00 per ton.

Phosphates in Foreign Countries

Africa

Next in importance to the phosphates of the United States are those of northern Africa. Mining operations have been very extensive in Tunis and Algeria since 1899, and the deposits of phosphate in Egypt are assuming a greater importance each year. Although the material is of somewhat lower grade than that of Florida, Tennessee and our western states, the nearness of the deposits to the foreign market has made them in recent years the chief source of phosphate fertilizer for European and Asiatic nations. The production from the African fields during 1918, as far as can be learned at present, amounted to 1,084,934 metric tons, as against 1,317,596 tons in 1917. The industry, however, has been considerably depressed, owing to high freight rates, lack of bottoms, and scarcity of labor.

Tunis.—Under normal conditions Tunis has an annual production of phosphate rock second only to that of Florida. The deposits are owned or controlled by French capital and up to the time of the war they were being mined at an ever-increasing rate. Much of the rock mined in this region prior to the war was shipped to Germany. The closing of that market undoubtedly had something to do with the curtailment of production. The output in 1918 was 818,962 tons, against 999,326 tons in 1917.

The main phosphate district is in the vicinity of Gafsa, which is connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs in gigantic lenses of considerable thickness and ranges in grade from 53 to 68 per cent. bone phosphate of lime. The mining is done by open cuts as well as by tunnels. The "Societé de Phosphate de Gafsa," which controls all the phosphate properties in the Gafsa region, is the largest single producer of phosphate in the world and up to 1914 had continually increased its annual output. The other companies in Tunis are the "Societés des Phosphates Tunisiens" and the "Compagnie des Phosphates du Dyr."

Algeria.—The phosphate deposits of Algeria are of the same general type as those of Tunis, but have not been developed and exploited to the same extent. The most important mining company in Algeria is the "Compagnie des Phosphates de Constantine." Its production in 1913 amounted to 314,168 tons. Other companies reported in this field are

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"Compagnie Centrale," "Compagnie Algerienne des Phosphates de Tocqueville," and the "Compagnie de M'Zatia." The production in 1918 amounted to 234,825 tons, which was an increase of 32,286 tons over the output of 1917.

Egypt (By R. H. Graves).—Deposits of phosphate occurring as beds in sedimentary strata are widely distributed in Egypt. They are very similar in character to those of Algeria and Tunis and present a field of considerable economic importance.

The land now let under mining lease forms a very small proportion of the total area known to contain phosphates, so that there is ample opportunity for prospecting enterprise. The localities in which phosphate is at present being mined are:

1. The Safaja district, near the Red Sea coast.
2. The Kosseir district, near the Red Sea coast.
3. The Sebaia district, on the east bank of the Nile.

The production for the past nine years was as follows:

	Metric Tons.		Metric Tons.
1910	2,397	1914	71,945
1911	12,013	1915	82,998
1912	70,918	1916	125,008
1913	104,450	1917	115,732
		1918	31,147

The rock phosphate is either shipped raw in bulk, or manufactured into a finished fertilizer, of which two kinds are at present made in Egypt, namely, "Ephos basic phosphate" and "Tetraphosphate"; these are exported in bags.

Prior to the war the greater part of Egypt's phosphate production was shipped to Japan, which took 75,565 tons in 1914. During hostilities the quantity exported has fallen, owing to high freight rates and the impossibility of obtaining sufficient shipping for the purpose. In 1916, for instance, only 20,526 tons was despatched, of which 17,521 was divided between the United Kingdom and the British Colonies.

The phosphate mines have nevertheless been kept working, though on a reduced scale, and the bulk of the output is now in stock awaiting shipping facilities. The quality of the rock phosphate varies considerably and may be roughly divided into three grades:

	Tricalcic Phosphate, Per Cent.	Iron and Alumina, Per Cent.
(1)	60.0	3.00
(2)	64.0	2.75
(3)	70.0	1.50

The phosphate produced in the Nile Valley is the lowest grade and is shipped from the port of Alexandria. The Red Sea districts produce the better qualities, which are despatched from the ports of Safaja

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and Kosseir. Port Safaja is a deep-water anchorage and has an installation for rapid mechanical loading.

Union of South Africa.—A recent report[1] states that phosphate deposits of considerable extent have been found in the Union of South Africa. The tonnage is said to be very great, but the rock is largely in the form of aluminium phosphate, which renders its conversion into acid phosphate difficult if not impracticable.

TABLE VII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA, TUNIS AND EGYPT
(In metric tons)

Year.	Algeria.	Tunis.	Egypt.	Year.	Algeria.	Tunis.	Egypt.
1898	269,572	.....	.....	1909	351,491	1,224,822	.....
1899	286,681	65,209	.....	1910	319,069	1,286,262	2,397
1900	277,896	171,288	.....	1911(*a*)	332,897	1,446,633	12,013
1901	278,185	178,019	.....	1912(*a*)	388,515	1,923,000(*b*)	70,918
1902	265,964	266,553	.....	1913	438,601	1,984,880	64,183
1903	301,112	360,621	.....	1914	355,140	1,427,161	86,571
1904	344,969	457,133	.....	1915	225,891	1,087,816	33,245
1905	347,747	529,645	.....	1916	380,211	1,034,498	20,526
1906	302,262	747,303	.....	1917	202,539	613,440	27,015
1907	343,085	956,958	.....	1918	234,825	818,962	9,346
1908	362,890	1,270,020	.....				

(*a*) Figures furnished by Charles Michel, Paris. (*b*) Estimate.

Islands of the Pacific and Indian Oceans

The phosphate deposits which occur in several islands of the Pacific and Indian Oceans are of the highest grade yet discovered. Among the most important phosphate-producing islands of the Pacific are Ocean Island (English), of the Gilbert Group; Tahiti and Makatea (French), of the Society Group; and the Island of Naru (Japanese), of the Marshall Group. In addition to these, Christmas Island in the Indian Ocean (English) contains a large tonnage of high-grade rock. The phosphate of Makatea Island is being exploited by a French company and it is said that the supply is very great. A number of phosphate deposits in the islands of the Pacific Ocean which formerly belonged to Germany are now in the hands of England and Japan and will, no doubt, be retained by these nations. No statistics are yet available showing the production from these islands during 1918. In 1917 the production on the island of Makatea was 32,259 metric tons.

Phosphate rock was also recently discovered in New Zealand and a company has been formed for the purpose of manufacturing sulphuric acid and acid phosphate to meet in part the fertilizer demand of this island. The growing use of fertilizers in New Zealand has caused the Government to offer bonuses for the discovery of commercial grades of phosphate. The annual production of phosphate rock amounts to 10,000 tons.

[1] *So. Afr. Min. Jour.*, Aug. 10, 1918.

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EUROPE

Russia.—Large deposits of phosphate rock occur in three regions of Russia, but the rock has been developed only by the Governments of Podolia and Bessarabia. Since the deposits in these regions lie close to the Austrian frontier, the Central Empires, no doubt, availed themselves of these deposits to meet in part at least the shortage in phosphate fertilizers caused by the cutting off of the supply normally obtained from the United States and Africa. It is estimated that the Russian deposits so far developed contain about 80,000,000 tons of phosphate. No statistics on Russian production of phosphate have been reported since 1913.

France and Belgium.—The phosphate deposits of France and Belgium at one time largely supplied the European demand for phosphate fertilizers, but the annual production from these sources just prior to the war had fallen off to such an extent that the output was but a very small percentage of the world's production. The great decrease in mining in these countries was due in part to the depletion of the deposits and partly to the discovery of the much higher grades of phosphate in other countries. Since France largely controls the deposits of phosphate in Tunis and Algeria, she has been obtaining her main supply of phosphate rock from these countries. Until the latter part of 1918, the phosphate areas of France and Belgium were in German hands and there is little doubt that they were being mined for the benefit of German agriculture.

Figures showing the amount of phosphate rock exported and imported by France during the past 7 years are, as far as they are available, shown in Table VIII.

TABLE VIII.—FRENCH IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons)

Year.	Imports.	Exports.
1912	903,489	22,062
1913	934,688	21,128
1914	(a)647,769	11,219
1915	(b)325,114	(b) 1,796
1916	285,906	1,437
1917	134,779	627
1918	228,927	36

(a) 10 months. (b) Provisional figures.

Germany.—The only deposits of phosphate rock owned and controlled by Germany were those on several insular possessions in the Pacific Ocean. These have been taken over by England and Japan, and Germany will now be forced to depend upon other countries for her supplies of this important mineral. The demand for phosphatic manures in Germany,

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however, can be partly met by a large production of basic slag, a by-product of the steel industry. Up to the time of the war, Germany was a large exporter of basic slag. For obvious reasons the statistics showing the production and consumption of phosphate and phosphatic slag in Germany during the period of the war are not available.

England.—While phosphate in the form of coprolites has been found in various parts of the British Isles, the deposits have not been of sufficient importance to meet the demands of that country for phosphatic fertilizer. England, however, controls the more important phosphate deposits of Egypt and those of exceptional richness and value on Ocean Island. In addition to these, a number of valuable deposits on other islands in the Pacific Ocean which formerly belonged to Germany have now passed into British hands. England also has a large annual output of basic slag, a product containing from 14 to 18 per cent. of available phosphoric acid. The imports and exports of fertilizer materials by England for the past 5 years are shown in Tables IX and X.

TABLE IX.—IMPORTATIONS OF PHOSPHATIC MATERIALS TO ENGLAND
(Metric tons)

Material.	1914.	1915.	1916.	1917.	1918.
Basic slag	16,838				
Guano	39,915	(a) 27,159	(a) 21,991	(a) 2,643	
Phosphate rock	564,521	(a)380,651	(a)338,721	(a)281,056	(a)472,205
Total	621,274	407,810	360,712	283,699	472,205

(a) Includes Ireland.

TABLE X.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND
(Metric tons,)

Material.	1914.	1915.	1916.	1917.	1918.
Superphosphate	67,111	(a) 69,838	(a)14,760	(a)3,284	2,588
Phosphate rock	2,646				
Basic slag	134,808	(a)119,373	(a)39,248	(a)1,854	1,082
Total	203,565	189,210	54,008	5,138	3,670

(a) Includes Ireland.

Spain.—No production of phosphate rock has been reported from Spain for 1918, but in 1917 28,148 tons was produced. The consumption of mineral phosphates in Spain has increased very greatly within the last 5 years, amounting to approximately 340,000 tons annually. The imports are given below in Table XI. Most of the phosphate used in Spain is imported from the deposits in northern Africa.

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TABLE XI.—IMPORTS TO SPAIN (a)
(In metric tons)

Material.	1914.	1915.	1916.	1917.	1918.
Phosphate rock	202,051	212,085	288,328	(b)126,266	115,028
Basic slag					
Superphosphate	(c)116,897	(c)63,013	(c)23,115	(c)12,106	11
Guano	1,339	946	1,281	2,398	988

(a) Figures obtained from Le Movement Int. des Engrais Chimiques, Rome. (b) January to October. (c) Includes basic slag.

South America

Peru.—At one time the deposits of guano owned and controlled by the Peruvian Government were of the greatest importance as sources of nitrogen and phosphoric acid. The Government has endeavored to conserve these deposits by limiting the time when the material may be mined or exploited and by enforcing certain regulations which prevent the birds which are responsible for these deposits from being disturbed during the breeding season. An English company, "The Peruvian Corporation, Ltd.," has been taking guano from the Lobos Islands off the coast of Peru since 1890. The Peruvian Government, however, in 1915 passed a law decreeing a preferential right in favor of national agriculture, thus canceling the former agreements with the above company. This stand was taken because it was maintained that the guano was being shipped out of the country to the serious detriment of the agricultural interests of Peru. On June 9, 1916, a decree was passed allotting to the corporation certain islands from which alone it was permitted to load guano. The corporation protested that these islands contain only small amounts of guano and many of the deposits are almost inaccessible. It has therefore declined to load guano under the conditions of this decree and none has been shipped by the corporation, as far as can be learned, since 1915.

Argentina and Uruguay.—These two South American countries export under normal conditions considerable amounts of guano and bone, both to the United States and foreign countries. The high freight rates, however, and the lack of carriers have seriously interfered with the exportations during the past few years. The exports as far as can be learned at present are given below in Table XII.

TABLE XII.—EXPORTS OF BONES AND GUANO FROM ARGENTINA AND URUGUAY

	1915.		1916.		1917.		1918.	
	Guano.	Bones.	Guano.	Bones.	Guano.	Bones.	Gauno.	Bones.
Argentina	19,476	16,519	15,159	20,452	17,891	25,118	14,509	5,912
Uruguay	1,435	1,837	(a)	(a)	(a)	(a)	(a)	(a)

(a) Statistics not available.

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Asia

Japan.—A few years ago, it was reported that phosphates of extreme richness had been discovered on Rasa Island at the extreme end of the Loochoo group. It was estimated that there were 2,800,000 tons in these deposits and that the rock averaged 77 per cent. bone phosphate of lime with only 2 per cent. combined oxides of iron and aluminium. Further examination of these deposits, however, showed that the material was so high in iron and aluminium that the manufacture of acid phosphate therefrom was extremely difficult. Therefore, the deposits have been developed to a relatively limited extent. The production from this island in 1915 amounted to 50,000 tons as against 28,022 in 1914. Japan has been getting much of her phosphate from Egypt, where the deposits are controlled by English capital. The high-grade phosphate deposits of the Marshall Islands (formerly a German possession) have passed into the hands of the Japanese and this country is mining the material at an ever-increasing rate. The importation of phosphates from various countries has not been reported for 1918, but the total quantities imported are given below in Table XIII.

TABLE XIII.—IMPORTS OF PHOSPHATE ROCK TO JAPAN

Country.	1912.	1913.	1914. (a)	1915.	1916.	1917.	1918.
England	.....	21,990	(b)	135,800	99,702	155,446	89,572
France	.....	.....	.....				
United States	74,700	38,740	54,063				
Egypt	10,220	29,700	68,157				
Other countries	198,000	238,150	144,702				

(a) From January to September, 1914. (b) Included in figures for other countries.

West Indies

A number of islands in the Caribbean Sea (notably Curacaro and Aruba) contain phosphate deposits of limited quantity but high quality. The disturbed conditions brought on by the war, together with the high freight rates and lack of bottoms, have seriously interfered with the output of phosphates from these islands and no production has been reported for 1918, but in 1917 4000 tons was produced.

Technology

Practically all of the phosphorus produced for war purposes during 1918 was obtained by the electric-furnace process, which consists in decomposing a mixture of phosphate rock, sand, and coke at the high temperature obtained in such a furnace, taking care that all air is excluded from the reaction zone and collecting the volatilized phosphorus

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under reducing conditions. There is every reason to expect that the volatilization process of producing phosphoric acid for baking-powder purposes will eventually supplant the present sulphuric-acid method, since the phosphoric acid obtained by the former plan can be collected in any desired concentration and in a very pure state. The electric-furnace method of obtaining phosphoric acid for fertilizer purposes, however, does not appear very promising, particularly since large quantities of sulphuric acid are now available for the manufacture of fertilizers.

While the signing of the armistice late in 1918 released immense tonnages of sulphuric acid to the fertilizer trade, considerable interest was evinced during the year and much effort expended in attempts to find a suitable substitute for the sulphuric-acid method of producing phosphatic fertilizers.

Blumenberg's Processes.—Henry Blumenberg of Los Angeles, Calif., has taken out several patents for producing phosphatic fertilizers without the aid of sulphuric acid. In one of these patents[1] the inventor claims to obtain calcium sulphite and phosphoric acid by treating finely ground phosphate rock with sulphur dioxide in the presence of water. The reactions he represents thus:

$$Ca_3(PO_4)_2 + 3SO_2 + 3H_2O = 3CaSO_3 + 2H_3PO_4$$

The calcium sulphite is filtered off and the phosphoric acid consumed as such or used in the manufacture of double superphosphate.

In Blumenberg's other process[2] he proposes to mix intimately finely ground phosphate rock and ammonium sulphate in proportions to react as follows:

$$Ca_3(PO_4)_2 + 3(NH_4)_2SO_4 = 3CaSO_4 + 2(NH_4)_3PO_4$$

He claims that the above reaction takes place if the mixture is added to the soil, but if it is desired to convert the phosphate into an available form before adding to the soil it may be done by heating the mixture until ammonia is driven off. The volatilized ammonia is collected and used again.

Gardiner's Processes.[3]—R. F. Gardiner of the Bureau of Soils has suggested a similar method of obtaining available phosphoric acid, potash and nitrogen by treating finely ground natural minerals containing potash and phosphoric acid with ammonium sulphate until gaseous decomposition products of the ammonium sulphate are copiously evolved. The volatilized products are collected or absorbed in some suitable manner and used in treating another batch of the minerals.

[1] U. S. Patent No. 1251741 (1918).
[2] U. S. Patent No. 1251742 (1918).
[3] U. S. Patents Nos. 1258106 and 1261116 (1918).

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Process of Borghesam and Stampa.[1]—These inventors claim to produce available phosphoric acid and potash by heating an intimate mixture of potash-bearing silicates, phosphate rock and sodium bisulphate (niter cake) in a furnace until a temperature of from 1200° to 1400°C. is obtained. The flux produced is then powdered and used as a basic phosphoro-potassic fertilizer.

Meadows' Process.[2]—Meadows also proposes to obtain a potassic-phosphatic fertilizer by heating in an autoclave a mixture of glauconite or greensand, acid phosphate and water. After the digestion is complete the charge is filtered. It is claimed that both the potash and phosphoric acid are contained in the filtrate as crude potassium phosphate.

Process of Haslup and Peacock.[3]—In this process a finely divided mixture of phosphate rock and carbon (coke) in excess is heated in a suitable furnace in the presence of a stream of producer gas to a temperature between 1200° and 1600°C. The reactions which it is claimed take place are represented thus:

$$(a)\ Ca_3(PO_4)_2 + 5C = 3CaO + 5CO + 2P$$

It is claimed that the lime and excess of carbon then combine with the nitrogen in the producer gas thus:

$$(b)\ CaO + 2C + N_2 = CaCN_2 + CO$$

The valuable products resulting from this treatment therefore are said to be phosphorus, phosphoric acid and cyanamide.

Preparation of a Rust-proofing Solution.—W. H. Allen[4] describes a method of obtaining a solution which will, he claims, give iron and steel surfaces a rust-proof coating. His process consists in blowing air through a solution of ferrous phosphate or allowing said solution to flow in a thin film over surfaces exposed to air or oxidizing influences so that the ferrous phosphate will be converted into the ferric condition, when it is suitable for giving the coating to surfaces which it is desired to render rust proof.

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[1] U. S. Patent No. 1272001 (1918).
[2] U. S. Patent No. 1276555 (1918).
[3] U. S. Patent No. 1281363 (1918).
[4] U. S. Patent No. 1271002 (1918).

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PLATINUM

By George Frederick Kunz

While during the great war the use of platinum for catalyzing purposes in the production of concentrated sulphuric acid for the manufacture of explosives, for dehydrating nitric acid, and for airplanes and other war machines has been made especially prominent, the wide employment of it in electric and other appliances is of equal importance. Large amounts of it have been used for dental work, because of its durability and its resistance to the action of acids. The latter reason has made it of the greatest possible value for various chemical vessels, such as crucibles, retorts, etc. Within the past ten or fifteen years it has been employed by manufacturing jewelers in many ways, for watch cases and for other of the smaller ornamental pieces, and for precious-stone settings, more especially for diamond settings. The cutting off of the Russian supply, the principal source of the metal, the imperative need of it for war purposes, and the consequent stringent measures taken by the various governments to restrain its exportation and its use, have operated to restrict these greatly, and have also induced an active search for substitutes which might prove more or less satisfactory. To this end alloys of gold and palladium, of gold and osmium, or of gold and nickel have been used with fairly good results in many cases. Of the 5,000,000 or more ounces of platinum in existence, it has been estimated very conservatively that catalyzing processes have claimed 500,000 oz., dental uses 1,000,000 oz., chemical apparatus 1,000,000 oz., electrical devices 500,000 oz. and jewelry 500,000 oz. These estimates are probably set rather too low in view of the fact that the total production of the metal has probably been as much as 6,000,000 oz.; indeed some authorities have placed the total Russian production alone as high as 7,000,000 oz. Of course, this was crude platinum and would furnish only about 5,800,000 oz. of the refined metal.

In the period from 1900 to 1918 the imports of unmanufactured platinum, and of bars and ingots, into the United States, have had a total weight of 54,482 kg., or 1,751,673 troy ounces, and a total value of $53,931,634. To this must be added imports of crucibles, retorts, etc., worth $2,316,461, giving a total value of platinum in all forms of $56,248,095. Of course a good proportion of the imports was crude platinum.

There is no doubt that the governments of England and the United States both had the foresight to secure platinum enough for several years

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use if the warfare had continued, and now that international negotiations are such that war seems to be at an end for the time being, the use of platinum has been relieved of restrictions and the metal has been released in small quantities from time to time, so as to keep the market stable and prevent a crash in prices. The United States Government offered its surplus platinum in the open market at a minimum price of $105 an ounce, and iridium at a minimum price of $200. Offers for less than 10 ounces are not accepted, and no more than 1000 ounces will be sold to a single purchaser, should it not be that exceptional circumstances warrant a change in this ruling. Cost must be paid in advance, and as far as possible, the delivery will be made in person to the purchaser. The platinum will be delivered either in grains or as platinum sponge. By July 23, 1919, 25,000 oz. had been taken by dealers, and it was stated that if the Government had been able to offer another 25,000 ounces the market would quickly have absorbed it.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK
(In dollars per troy ounce)

	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
January.....	29.00	39.06	46.00	45.50	43.38	41.10	90.05	87.83	105.92
February.....	28.75	39.31	45.63	45.50	43.50	40.00	90.00	103.75	107.68
March.....	29.13	41.00	45.50	45.50	43.50	39.50	90.75	104.33	108.00
April.....	29.25	41.35	45.50	45.50	43.50	38.63	83.10	103.77	108.00
May.....	29.55	42.81	45.50	45.50	43.50	38.50	80.50	105.00	106.27
June.....	31.38	42.88	45.50	45.50	43.50	38.00	78.13	104.75	105.00
July.....	33.00	42.95	45.50	45.50	43.50	38.00	63.60	103.88	105.00
August.....	33.00	44.38	45.50	44.90	50.20	39.25	62.56	104.55	105.00
September....	33.63	45.31	45.50	43.96	50.00	50.00	84.25	104.13	105.00
October.....	37.50	46.25	45.50	44.00	49.50	54.50	89.75	104.00	105.00
November....	39.44	46.13	45.50	43.70	45.45	62.63	101.25	104.52	105.00
December.....	38.75	46.00	45.50	43.45	42.19	85.50	86.87	104.38	105.54
Year.....	32.70	43.12	45.55	44.88	45.14	47.13	83.40	102.82	105.95

The scarcity of platinum stimulated quite a demand for the rarer, allied metal, palladium, which was but infrequently used prior to 1914. The price rose rapidly until the troy ounce commanded as much as $165, when the Government interposed and established a maximum price of $135 an ounce. While the quantity sold in 1915 was but 958 oz., the figures for 1917 show that above 3300 oz. was disposed of in that year. This of course stimulated production, that of 1918 being some 75 per cent. greater than in 1917.[1] A very considerable quantity of palladium has been secured from the copper matte of the Sudbury nickel-copper mines in Ontario, Canada, and the production from this source could be largely increased.

The average monthly prices for palladium in the United States are reported to have been as follows in dollars per ounce, for 1917 and 1918;

[1] H. C. Meyer, *Eng. Min. Jour.*, Jan. 11, 1919.

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the slight decrease in December, after the removal of the Government restriction of $135 per oz., will be noted and, of course, indicates the future trend:[1]

	1917.	1918.		1917.	1918.
January	$73.00	$135.00	July	$113.60	$135.00
February	88.32	137.50	August	120.00	135.00
March	88.05	144.04	September	123.44	135.00
April	93.70	150.00	October	121.92	135.00
May	104.00	142.31	November	126.87	135.00
June	108.29	135.00	December	130.60	128.60

The lot of crude platinum brought to the United States from Russia by Mr. F. W. Draper[2] had been collected during the year 1917 by the Russian-English Bank; it was delivered to the United States Government early in 1918. At the New York Assay Office the exact weight of this material, which consisted of grains and nuggets, was found to be 20,922 oz. From this were obtained 17,640 oz. of platinum, 64.75 oz. of palladium, 182.11 oz. of iridium and 48.56 oz. of rhodium. Hence the crude material as imported contained 85.725 per cent. of the platinum metals, this being above the usual average of 83 per cent. As the value of all this refined product, making due allowance for the rhodium, was about $1,900,000 at Government maximum prices, the $2,000,000 said to have been paid for the consignment of the crude material does not seem to have been at all an undue price. All the platinum acquired by the United States Government, comprising crude platinum, scrap platinum, and platinum sponge, was refined at the New York Assay Office, the total weight, including the Russian shipment, being over 60,000 oz.

IMPORTS OF PLATINUM INTO THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1918, BY COUNTRIES OF ORIGIN

Country Whence Shipped.	Unmanufactured.			Ingots, Bars, Plates, etc.		Vases, Retorts, Value.
	Troy Oz.	Grams.	Value.	Troy Oz.	Value.	
France	166	5,163	$18,142	814	$78,674	.....
Netherlands	.....	.....	.....	.....	.....	$165
England	1,073	33,370	80,834	357	29,614	.....
Canada	76	2,364	7,249	253	23,671	1,682
Panama	372	11,569	35,254	.....	.....	.....
Mexico	9	280	749	.....	.....	.....
Cuba	.....	.....	.....	3	260	.....
Brasil	27	840	2,312	.....	.....	.....
Chile	3	93	300	.....	.....	.....
Colombia	25,365	788,851	2,112,211	1,665	129,533	700
Peru	3	93	300	.....	.....	.....
Venezuela	162	5,038	12,960	.....	.....	.....
China	489	15,208	38,207	.....	.....	.....
Russia in Asia	21,000	653,100	2,000,000	.....	.....	.....
British South Africa	.....	.....	.....	25	2,344	.....
	48,745	1,515,969	$4,308,518	3,117	$264,096	$2,547

[1] *Eng. Min. Jour.*, **107**, No. 2.
[2] MINERAL INDUSTRY, **26**, 535, 550 (1917).

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This gives an average value of $83.39 per troy oz. of the unmanufactured platinum.

STATISTICS OF PLATINUM IN THE UNITED STATES

Year.	Production. (a)		Imports.			Total.
			Unmanufactured. (b)		Manufactured.	
	Troy Oz.	Value.	Troy Oz.	Value.	Value.	Value.
1901	1,408	$27,526	85,438	$1,673,713	$24,482	$1,725,721
1902	94	1,814	105,450	1,950,362	37,618	1,989,794
1903	110	2,080	114,521	1,921,772	135,889	2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,922,038
1905	318	5,320	104,196	1,985,107	188,156	2,178,583
1906	1,439	45,189	137,556	3,601,021	187,639	3,833,849
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,245,084
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	1,034	46,530	117,947	4,938,706	105,553	5,090,789
1914	3,430	154,350	72,267	2,934,580	39,143	3,128,073
1915	6,495	322,347	61,437	2,340,476	71,532	2,734,355
1916	24,518	2,044,801	53,484	3,138,396	18,923	5,202,120
1917	33,009	3,393,985	30,316	2,414,773	382	5,809,140
1918	.....	.....	54,962	4,949,755	14,225	.....

(a) Statistics of the U. S. Geol. Surv. Recovered by refiners. (b) Includes ingots, bars, plates, etc.

SECONDARY PLATINUM AND ALLIED METALS SOLD, 1915–1917
(Troy ounces)

Year.	Platinum.	Iridium.	Palladium.
1915	42,149	863	958
1916	45,156	1,535	1,284
1917	59,007	9,832	3,347

IMPORTS OF THE ALLIED PLATINUM METALS INTO THE UNITED STATES FOR THE YEARS 1916–1918

	Os. Troy.	Grams.	Value.	Aver. Per Oz.	Aver. Per Gram.
1916					
Iridium	3,346	104,071	$250,705	$74.93	$2.41
Osmiridium	414	12,877	17,241	41.46	1.34
Osmium	.....	.....	.....	.....	.....
Palladium	6,513	202,595	282,910	43.43	1.40
1917					
Iridium	3,619	112,562	$378,678	$104.64	$3.37
Osmiridium	259	8,056	25,456	98.28	3.16
Osmium	400	12,441	23,359	58.40	1.88
Palladium	1,239	38,537	117,192	94.60	3.04
1918					
Iridium	1,106	34,400	$126,282	$114.18	$3.67
Osmiridium	427	13,281	46,321	108.48	3.49
Osmium	.....	.....	.....	.....	.....
Palladium	240	7,465	36,853	153.55	4.93

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Sources of Platinum in the United States

Alaska.—In connection with the prospects of mining for the platinum metals in Alaska, it is interesting to note that palladium is reported to have been obtained from the copper ore of the Salt Chuck mine, near Ketchikan in that Territory; some platinum was also recovered. From Dime Creek in the Koyuk district of Seward Peninsula more platinum was taken from gold placers in 1918 than during the previous year, the amount secured being 56 oz. A little of this, however, came from Bear Creek, in the Fairhaven district.[1] A rich platinum find has been credited to the Gum and Nome group of claims on the south fork of the Kaslo River.[2]

Arizona.—Very careful investigation of samples taken from various localities in the Grand Canyon, Arizona, where the existence of platinum had been reported, has failed to verify the report. Two samples taken by Mr. F. L. Ransome, of the United States Geological Survey, in the summer of 1918, were each divided into three parts, and were submitted to the Bureau of the Mint, the Bureau of Standards, and the United States Geological Survey, respectively. The results were negative, as had also been the case with a sample taken in 1911 by Mr. Ransome from near Indian Garden. In 1915, samples were taken from this last-named locality by Mr. H. G. Ferguson of the Survey, and thirty of them were assayed for platinum by Ledoux & Co., of New York, five other samples being tested by E. E. Burbingame & Co. of Denver, but no platinum was found in any instance.[3]

California.—The distribution and value of the platinum production of California in 1917 is given as follows:[4]

County.	Ounces.	Grams.	Value.	Value per Oz.
Butte	119	3,701	$9,106	$76.51
Calaveras	20	622	1,433	71.65
Del Norte	10	311	853	85.30
Humboldt	6	187	351	58.50
Sacramento	157	4,883	12,453	79.20
Shasta	14	435	1,100	78.57
Siskiyou	15	467	709	47.27
Trinity	50	1,555	3,283	65.66
Yuba	149	4,634	8,869	59.52
Amador, El Dorado	.....	.....	.....	.....
Merced, Nevada	.....	.....	.....	.....
Placer, San Joaquin	.....	.....	.....	.....
Stanislaus	70	2,177	5,562	79.46
	610	18,972	$43,719	$71.67

The glowing expectations as to platinum returns from the black sands of the Pacific Coast seem doomed to disappointment, according to the

[1] U. S. Geol. Surv.
[2] *Can. Min. Jour.*, Aug. 1, 1918.
[3] *Press Bull.*, U. S. Geol. Surv., Jan., 1919.
[4] "California Mineral Production for 1917." Walter W. Bradley, Mining Statistician, Sacramento 1918, p. 41. The weight in grams and the average price per ounce troy have been added here.

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findings of the Bureau of Mines, which has been conducting investigations in the matter. While platinum is frequently present in the sands, there is usually not enough either of this metal or of gold to render operations profitable, except in a few favored spots. As the processes now in use have commonly given negative results, those seeking to interest investors in the exploitation of the black sands have not infrequently claimed the discovery of new processes or machines far superior to any yet known, the results being unfortunate for those sanguine enough to invest.[1]

Idaho.—In regard to one of the supposed platinum sources in our western regions, we have the following statement from Robert N. Bell, State Inspector of Mines in Idaho.[2]

"Investigations were made of reported big platinum ore deposits in the Priest Lake district of Bonner County, whence some specimens of ore were received that gave 0.2 oz. platinum per ton, but an examination of the large and small deposits of pyrrhotite ore in silicious schist, from which the specimen was said to have been derived, failed to show appreciable values in platinum in average samples."

WORLD'S PRODUCTION OF NEW PLATINUM IN 1914–1917, BY COUNTRIES
(In troy ounces)

Country.	1914.	1915.	1916.	1917.(a)
Russia, crude	(a)241,200	(a)124,000	(a)90,000	50,000
Canada, crude (b)	(a)30	(a)100	(a)60	80
New South Wales and Tasmania, crude (c)	(a)1,248	303	222	(f)
Colombia, crude	(a)17,500	18,000	25,000	32,000
United States, domestic crude	570	742	750	605
United States, refined from foreign and domestic matte and bullion (d)	2,905	5,753	2,556	7,384
Borneo and Sumatra and other crude (e)	(f)	(f)	(f)	(f)
Total	263,453	148,898	118,588	90,069

(a) Estimated. (b) In addition to platinum contained in matte and bullion refined in the United States. (c) Chiefly iridosmine. (d) Does not include refined platinum from domestic crude. (e) Includes small production in Madagascar. (f) No basis for estimate.

Platinum in Foreign Countries

Australia.—Osmiridium in considerable amount is stated to have been found in serpentine rock from the Hazelwood hills in the Waratah district, Tasmania. A sample of the rock brought to Hobart weighed 13 or 14 lb. and was estimated to contain at least £50 or £60 worth of the precious metal. There were seams of osmiridium, as well as hundreds of small particles disseminated through the rock in a manner similar to the dissemination of gold particles in quartz. The alluvial deposits of the district are being actively worked, and the discovery of osmiridium-bearing rock is especially interesting, as it appears to be the source of

[1] *Chem. Met. Eng.*, Feb. 1, 1919.
[2] Twentieth Annual Report of the Mining Industry of Idaho, for the year 1918, pp. 110, 111.

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deposits in gullies and creeks. Three nuggets have been found here, weighing 1, 2 and 3 oz. troy, respectively.[1]

Canada.—The recorded production of Canadian platinum, all derived from the placer gravels of the Similkameen district of British Columbia, was 39 oz. crude in 1918, estimated to be equivalent to 25 oz. fine; the value was $2560. In 1917 the recorded output was 57 oz. crude and the value $3823. This, however, only covers a small part of Canada's platinum output, for it takes no account of the quantity secured by treating the matte from the great nickel-copper mines of the Sudbury district in Ontario. Some approximate idea of the quantity from this source is afforded by the reports of the International Nickel Co. for the years 1907 to 1916; these show a yearly recovery of 1000 oz. of platinum and palladium, but as material from some other mines than those of Canada were treated, the entire quantity cannot be credited to that country. The platinum exports from Canada in 1918 are thus stated: platinum in ore, concentrates, etc., 12 oz., valued at $1798; old and scrap platinum, 185 oz., valued at $20,094. For 1917 the returns were 136 oz. of platinum in ore, concentrates, etc., having a value of $11,309, and 195 oz. of old and scrap platinum, valued at $18,290. The potential resources in platinum and palladium of the Sudbury ores are brought out in the reports of the Canadian Copper Co., which give 0.10 oz. of platinum and 0.15 oz. of palladium for a ton of matte. If we apply this standard to the 86,773 tons of matte shipped from Canada in 1918, we would have returns of 8677 oz. of platinum and 13,016 oz. of palladium, which at a price of $105 per oz. of platinum would give $911,085 for the platinum, while at $135 per oz. the palladium would be worth $1,757,160, or together $2,668,245. Of course these "war prices" will scarcely be maintained.[2]

In the course of the year 1918, the scarcity of platinum led the Canadian Government to take measures for the encouragement of production in western Canada, and the placers of the Tulameen River were prospected by representatives of the Imperial Munitions Board. From their reports it seemed likely that if energetically worked the deposits could be made to yield considerably more of the metal than formerly. In anticipation of this the Vancouver Assay Office was established, as well as for the treatment of any supplies that might be brought in by companies or individuals operating elsewhere. The war need having ceased it has been announced that no more platinum will be purchased by this assay office, although there is a good probability that it will be kept in operation for the convenience of those who may wish to avail themselves of

[1] *Queens. Govt. Min. Jour.*, Sept. 16, 1918.
[2] Prelim. Rept. Min. Prod. of Canada, Can. Dept. of Mines, 1918.

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it. During 1918, as many as 189 assays of platiniferous ores were made, and 77 deposits of platinum were received.[1]

It has been authoritatively reported that the Munitions Resources Commission of the Dominion Government had a drill at work on the Saskatchewan River and another on the Peace River in British Columbia. Thorough tests are being made of the deposits on the Tulameen River. Three drills were being operated successfully for prospecting in the placer grounds of the river.[2] It has also been stated that a Tacoma company erected a dam, a flume, and centrifugal pumps, and started to work the bed of the river.[3]

There seems to be a good prospect of securing platinum from the Franklin Camp, near Grand Forks, British Columbia. Two samples from the "Maple Leaf" claim taken from an open cut from which two cars of copper ore have already been shipped were found to contain, respectively, 0.15 oz. and 0.17 oz. of platinum per ton. As the proportion of platinum seemed to be related to that of the chalcopyrite in the ores, a sample of almost pure chalcopyrite was assayed, and was found to contain as much as 0.38 oz. of platinum to the ton. It has not yet been determined whether the metal occurs as native platinum, or as the arsenide of platinum known as sperrylite, but the probabilities are said to favor the latter form. In any case further investigation will be necessary to ascertain the commercial value of the occurrence.[4]

STATISTICS OF PLATINUM IN CANADA (a)

Year.	Production, Crude.		Exports.		Imports, Value.	
	Troy Oz.	Value.	Troy Oz.	Value.	Wire, Bars, Etc.	Crucibles, Retorts, Etc.
1907	.....	.....	242	$4,864	$89,719	$6,389
1908	.....	.....	43	937	37,223	7,030
1909	.....	.....	466	2,118	61,441	13,049
1910	.....	.....	2,254	62,776	100,185	12,874
1911	.....	.....	39	1,961	170,944	4,549
1912	.....	.....	92	3,821	224,216	7,974
1913	18	$489	158	7,929	141,117	4,557
1914	.....	.....	43	2,161	69,736	9,937
1915	23	1,063	236	11,052	65,040	19,047
1916	15	600	532	41,945	68,633	19,910
1917	57	3,823	331	29,599	107,409	6,870
1918	39	2,560	(b)375	36,755	(b)20,771	(b)7,239

(a) Annua Rept. Min. Prod. of Canada. (b) Dept. of Trade and Commerce, year ending Mar. 31, 1919.

Colombia.—As was generally expected, the increased demand for platinum coupled with the almost total cessation of the Russian supply of this metal stimulated production in Colombia, where the alluvial deposits

[1] *Can. Min. Jour.*, Jan. 29, 1919.
[2] *Can. Min. Jour.*, Aug. 1, 1918, and Sept. 15, 1918.
[3] *Min. Sci. Press*, Dec. 7, 1919.
[4] *Can. Min. Jour.*, Feb. 5, 1919, p. 79.

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of the Chocó River and in the basins of the San Juan and Condoto rivers were actively exploited. The estimate is made that the total output for the year 1918 was about 35,000 oz. So far there has been no confirmation of rumors to the effect that the Colombian Government contemplated taxing and limiting exports of the metal, as a retaliatory measure for the failure of the United States to ratify the treaty providing for a payment of $25,000,000 to Colombia on account of the concessions made by that country in the matter of the Panama Canal.[1]

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA
(In troy ounces)

Year. (a)	Quantity.	Value.
1910	1,600	$31,883
1911	5,503	147,820
1912	6,627	219,128
1913	10,461	363,731
1914	12,387	398,657
1915	13,601	470,938
1916	25,588	1,473,553
1917	21,278	1,536,422
1918	27,030	2,241,744

(a) Fiscal year ending June 30.

The recent organization of the South American Gold and Platinum Company by Adolph Lewisohn & Sons promises a large increase in the production of platinum in Colombia. The company has secured about 10,000 acres of land and also 50 miles of river bottom and flats. Part of these holdings has been in the possession of a British company which had already worked there for gold and platinum. There can be no doubt that the best methods will now be introduced, and that the mining operations will be carried on energetically. Besides the firm above mentioned, the Consolidated Goldfields of South Africa, and the Goldfields American Development Co., as well as the great platinum firm Johnson, Matthey & Company of London, are also shareholders. The authorized capital is 1,750,000 shares of $5 each, par value. All of this has been already subscribed for at $10 per share, and an agreement has been made that none shall be sold for three years.

As the product of gold and platinum secured by the limited operation of the past year was worth $700,000, the prospects are excellent for greatly increased returns in the near future, when the new machinery that has already been ordered is put in place and set working. Colombia has long ranked second in platinum production, although far behind Russia, but apart from the disorganization in the latter country, a state of things that must eventually be overcome, there has been a progressive exhaustion of the Russian deposits, and there is some prospect that with intensive mining

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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in Colombia that land may before very long displace Russia as the chief source of this extremely valuable and useful metal.

The managing director of the British Platinum & Gold Corp., Ltd., Mr. Thomas J. Ive, stated at the statutory meeting held in London last November that the corporation owned at that time 19½ sq. mi. of platinum and gold lands. The area can be greatly enlarged, for options have been acquired covering 25,000 acres or about 40 additional square miles of river lots and frontages, all available for dredging and hydraulicking. In addition to this, the corporation has secured the first right to take up options for purchasing the mining rights on promising areas covering 50 sq. mi., so that it has, practically, the privilege of enlarging the extent of its present holdings by about 90 miles. In the Opogodo property, extending over some 10 sq. mi., the corporation owns a half undivided interest. The other half is owned by the Paris Transvaal Gold Mines, Ltd., and there is some prospect of an eventual amalgamation of these two interests. Here about 1360 acres have been tested by the engineers, 4,000,000 cu. yd. having been proved by shafts and bores on the dredging area, and 60,000,000 cu. yd. on the hydraulicking area. In the gravels the proportion of the gold to the platinum has been found to be about 75 per cent. of the former to 25 per cent. of the latter, the estimate being made that the realizable profit will be £1,700,000. The corporation owns about 10½ sq. mi. of the Cimarronas property, whose total extent is about 12 sq. mi., and which from tests similar to those on the Opogodo property promises a yield worth £140,000 net value. The worth of the platinum has been put in these cases at £12 ($58.40 at normal exchange) per oz. for crude, and £14 10s. ($70.56) for refined platinum, the contents of the crude material being rated at 82 per cent. As to facilities for transport, the properties are well situated, since the whole sphere of operations is within easy reach of the San Juan River, and this stream is navigable by regular coasting steamers for 100 miles from its mouth, and after this point by river steamers.[1] Thus the output can easily be brought down to the coast and the needed machinery can be shipped from the port of Buenaventura to within a short distance of the properties.

Madagascar.—The search after platinum has extended to the great island colony of France, Madagascar, and the eminent French mineralogist, M. Alfred Lacroix, has recently communicated some details in regard to the presence of the metal there.[2] During the past few years small quantities of platinum have been found in the sediments of some rivers on the eastern coast of the island. It accompanies gold, in small rolled grains the surface of which is sometimes polished, more rarely

[1] *Min. Jour.*, Nov. 30, 1918, p. 700.
[2] *Bulletin de la Societe Francaise de Mineralogie*, 41, Nos. 4, 5, 6, Apr.–June, 1918, pp. 98, 99.

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pitted; occasionally there is a covering of iron oxide. No peridotite is known in the hydrographic basin of these rivers, but the geology of these regions is so imperfectly established as yet that one cannot draw definite conclusions from the negative evidence.

The localities reported are as follows, proceeding from north to south:

1. To the northeast of Fenerive: the Manantsatrana and its affluents on the right, comprised between the Tsalarazana and the Sasalaza (notably near Marosampana.)

The right bank of the Bikera and especially to the southeast of its entrance into the Marosampana.

2. To the south-southwest of Vatomandry, west of Marosiky: the Sahanimora River, an affluent of the Vatana, notably near Ambia, and the Vatana itself from the point of its confluence with the Sanhanimora. According to a report of M. Lavila, the platinum of the alluvia of this region would be to the gold in the proportion 1:5.

Near Ampasimpotsy, on the Farafara, an affluent of the Manampotsy, to the westward of Anosibe: the platinum of this river is in larger grains than that of the preceding region.

3. The Isonjo, an affluent of the Manambiha, which is itself an affluent on the left of the Mananara. It is in the neighborhood of the port of Bemalaha that, in 1904, platinum was found for the first time in Madagascar.

M. Molinié, the distinguished chemist of the Comptoir Lyon-Alemand, made the following analysis of a specimen coming from the southwest of Vatomandry:

	Per Cent.
Platinum	82.06
Iridium	1.85
Palladium	0.30
Rhodium	0.70
Gold	2.10
Iron	7.00
Copper	1.00
Iridosmine	1.30
Sand	2.30
Loss (difference)	1.39
	100.00

The gold which accompanies the platinum is of a high standard; it contains only 3.75 per cent. silver.

The official statistics of Madagascar give the following data as to the production of platinum from 1909 to 1911.

	Grams.
1909	27.80
1910	283.35
1911	147.15

Since this time it appears that the search for the precious metal has been abandoned. It is desirable that serious prospecting be undertaken in the regions indicated above.

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Rhodesia.—In the active search that has been recently prosecuted for platinum, attention has been paid to the chances of finding the metal in Southern Rhodesia. In this connection some properties in the Gwelo district were examined by Mr. Zeally, who was so favorably impressed by the conditions observable in a particular reef that he sent a quantity of the concentrate derived from it to the Imperial Institute for testing. The director reported 1 dwt. 20 grains of platinum per ton, which he pronounced to be a sufficient quantity to make working profitable.[1] This would be equivalent to nearly 0.092 oz. per ton. The result of an assay made in the Imperial Institute of a sample of the heaviest fine concentrate obtained in workings of the Somabula gravels, South Rhodesia, showed a very considerable amount of the platinum metals. The director of the Southern Rhodesia Geological Survey reports, Feb. 17, 1919, that the indicated amount of platinum per ton of concentrate was 3 oz. 12 dwt., besides which 7 oz. of osmiridium was present. The quantity of palladium proved too small to be determined; there was also a considerable gold content.[2]

Russia.—No information has been received concerning the output and position of platinum in Russia during 1918. The following tables give the production for recent years.

PRODUCTION OF PLATINUM IN RUSSIA

Year.	Official.	Actual.	Year.	Official.	Actual.	Year.	Official.	Actual. (a)
	oz.	oz.		oz.	oz.		oz.	oz.
1899 ...	191,464	380,900	1905.....	167,950	200,450	1911.....	187,008	280,000
1900.....	163,060	212,500	1906.....	185,546	210,318	1912.....	177,596	300,000
1901.....	203,257	315,200	1907.....	172,064	310,000	1913.....	157,735	275,000
1902.....	197,024	380,806	1908.....	156,792	250,000	1914....	157,182	240,000
1903	192,976	226,000	1909.....	164,513	275,000	1915.....	119,789	124,000
1904.....	161,950	290,120	1910.....	176,334	300,000	1916.....	78,682	90,000
						1917.....	.....	50,000

PRODUCTION OF PLATINUM IN THE URALS
(In troy ounces)

District.	1912.	1913.	1914.	1915.	1916.
South Verchotur.....	118,281	102,554	106,531	80,985	52,353
North Verchotur.....	13,061	11,376	7,426	12,288	9,968
Perm.....	38,706	36,880	38,051	22,996	14,818
Tcherdinsk.....	6,166	6,109	4,753	3,518	1,542
South Ekaterinburg.....	(c)1,382	816	421	(b)2	.....
Total.....	177,596	157,735	157,182	119,789	78,682

(a) Estimated. (b) Includes 2 oz. from North Ekaterinburg. (c) 5 oz. from North Ekaterinburg.

From Omsk the report comes that a credit of 31,000,000 rubles has been opened for the purchase of platinum. As the actual value of the

[1] *So. Afr. Min. Jour.*, June 22, 1918.
[2] H. B. Maufe, Director of the Rhodesia Geological Survey, in Report No. 5 of the Southern Rhodesia Geological Survey. *So. Afr. Min. Eng. Jour.*, Apr. 12, 1919, p. 182.

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ruble is so uncertain, and fluctuating, it is not easy to say how much this would mean in our money. The eventual worth would probably depend upon the chances of the Omsk Government for control of Russia, chances which are considered to be rather good at this writing.

Spain.—The extent of the platinum deposits in the Serranía de Ronda, as determined by investigations conducted from January, 1915, to October of that year, and since February, 1916, has been announced by the Geological Institute of Spain in a volume issued in 1917.[1] The precise area of the deposits has not been accurately ascertained, but its great extent is indicated by the fact that it embraces twelve or fourteen rivers, the beds of which contain platiniferous material, enough being present to furnish profitable working by dredges for many years. The deposits are loose peridotite sands which are found in the river beds at a depth of from 10 to 15 meters. The engineers in making their report in October, 1915, recommended a more thorough examination, and believed that this could only be concluded in the course of 4 or 5 years, and that the expense would perhaps reach $60,000. This did not deter the Government from beginning the further investigation recommended, which has been in progress since February, 1916, the investigating committee not confining its researches to platinum alone, but also seeking for deposits of magnetite, chrome and nickel. Up to June, 1916, some 3½ kilometers of the Rio Verde had been examined, this zone being chosen as presumably an average one. The platinum content here increased gradually from 0.08 gram per cubic meter of material at the lower end up to 0.2 gram per cubic meter at the highest point attained before the report. While these results are regarded as very encouraging, they of course need to be completed by the further investigations that will be carried out.

[1] Memorias del Instituto Geológico de España, "Estudio Geológico y Petrográfico de la Serranía de Ronda," Madrid, 1917.

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POTASSIUM SALTS

By J. W. Beckman

The combined demands for potash in the agricultural industries as well as in the more directly affected war industries were the driving impulses behind all activities relative to potash in the United States, and these activities gave promising indications, indications which speak well for the future. The sudden ending of hostilities on Nov. 11, 1918, may to some extent have dealt a death blow to our most extensive potash developments. But this is a matter of the future and is dependent on many varied European political matters about which there is no means at the present time of predicting. The total production of potash materials in the United States during 1918 was 206,567 short tons, containing 54,562 short tons of actual potash (K_2O).

Mr. W. B. Hicks of the United States Geological Survey summarizes in the following tables the sources from which the potash was derived and the type and quantities of products marketed:

POTASH PRODUCED IN THE UNITED STATES
(Short Tons)

Sources.	Number of Producers.		Total Production.		Available Potash (K_2O).	
	1917.	1918.	1917.	1918.	1917.	1918.
Natural brines	10	27	79,876	149,052	20,652	39,716
Alunite	3	4	7,153	6,180	2,402	2,621
Dust from cement mills	8	12	13,582	12,652	1,621	1,549
Kelp	10	8	11,306	14,029	3,572	4,804
Molasses distillery waste	4	8	8,589	11,792	2,846	3,476
Steffens waste water	5	51	2,642	1,100	369	643
Wood ashes	49	7	1,035	8,243	621	1,213
Other sources	6	9	2,778	3,519	490	529
Totals	95	126	126,961	206,567	32,573	54,562

POTASH SOLD IN THE UNITED STATES IN 1918
(Short Tons)

Product Marketed.	Total Production.	Variation in Content of K_2O.	Average Content of K_2O.	Available Potash (K_2O).
Muriate	30,127	38 to 58.5	41.8	12,614
Low-grade chloride	6,559	10 to 20.0	13.6	894
Sulphate	6,672	25 to 51.0	47.9	3,188
Crude sulphate and carbonate	122,741	18 to 38.0	25.5	31,311
Crude carbonate and caustic	609	50 to 78.0	60.0	365
Potash, char, ash and ground kelp	14,630	12 to 42.5	19.8	2,896
Cement and blast-furnace dust, alum, raw and calcined alunite	11,249	2.5 to 13.0	7.7	867
	192,587		27.0	52,135

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Our production in 1918 was almost double that in 1917. About 75 per cent. of the total output came from natural brines, and Nebraska brines alone supplied 55 per cent. of the total potash produced. Most of the potash produced in the United States was a mixed product, suitable for fertilizers containing from 20 to 30 per cent. of K_2O. Twenty-five per cent. of the output was in the shape of potassium chloride and 6 per cent. in sulphate form.

The United States had imported during the years prior to the war about 240,000 short tons of actual potash (K_2O) annually. Therefore, in 1918, 23 per cent. of the normal consumption was produced, and though this is not a very good showing, it is a good sign that the United States, with due care and encouragement of the potash industries, could become completely independent of foreign potash sources.

The present producing capacity of United States potash plants is shown in the following table:

Sources.	Available Potash (K_2O), Short Tons.
Nebraska lakes	50,000
Other natural brines	28,000
Alunite	4,000
Dust from cement mills	3,500
Kelp	5,500
Molasses distillery waste	4,000
Steffens waste water	3,000
Wood ashes	1,000
Other sources	1,000
	100,000

This figure of 100,000 tons gives a total production capacity of 40 per cent. of the normal potash consumption of the country.

IMPORTS OF POTASSIUM SALTS (a)
(Tons of 2000 lb.)

	1914.		1915.		1916.		1917.		1918.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bicarbonate (crude)	.....	.....	2,038	$83,502	770	$53,752	1,409.6	$233,111	363.8	$112,235
Bicarbonate (refined)	239	$22,767	192	20,341	60	22,596	1.1	1,259	85.8	84,381
Carbonate (crude)	4,523	240,451	4,310	291,341	222	27,689	484.7	185,810	6,591.9	2,928,289
Carbonate (refined)	5,211	368,858	1,189	92,959	87	38,604	101.2	52,170	222.6	124,019
Chloride	263,039	7,925,781	102,882	3,660,353	2,126	466,888	678.7	174,806	596.0	156,979
Chlorate	20	3,408	14	4,614	.....	.....	218.7	193,738	501.5	355,478
Chromate	17	2,822	20	3,317	1	391	1.2	962	.....	8
Cyanide	618	183,259	474	143,331	27	9,311	35.7	49,513	6.7	3,150
Hydrate	4,292	338,627	2,497	225,002	20	9,222	37.4	33,648	5.9	4,398
Kainit	589,245	2,579,619	79,124	444,996	64	1,795	.....	.....	.....	.....
Nitrate (crude)	1,773	115,344	339	22,483	2,766	761,818	5,085.8	904,506	4,410.2	955,018
Nitrate (refined)	182	20,173	34	4,222	2	749	322.6	35,143	43.0	16,193
Prussiate (red)	45	15,325	42	14,922	1	3,182	2.3	10,425	5.0	18,495
Prussiate (yellow)	1,754	390,021	1,158	255,711	22	31,651	20.6	32,251	67.3	111,096
Sulphate	50,384	1,887,491	21,705	1,071,623	2,427	197,808	734.7	20,538	136.0	19,837

(a) For the fiscal years ending June 30. For 1917 and 1918, calendar years.

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Potash from Lakes in Nebraska

An area of about 8000 sq. mi. of the north central portion of Nebraska is covered with a succession of low sand dunes. This region is bounded on the north by the Niobrara River, and on the south by the North Platte River, which rivers apparently were the barriers of the prairie and forest fires that are thought to be partly responsible for the present topography.

According to A. C. Whitford, the origin of the hills is as follows:

At the close of the glacial epoch there were one or two large rivers running eastward across Nebraska which overflowed their banks periodically and produced very extensive flood plains. At the close of each periodical inundation there followed a long drought accompanied by high westerly winds. This condition piled up sand dunes similar to those along Lake Michigan and caused the present topography of the sand-hill region. Later, when the present climate evolved, the hills gradually grassed over and were possibly forested, which vegetation became the subject of Indian fires. The burning of large tracts caused secondary shifting of the sand and, to some small extent, the present contour of the hills.

The genesis of the sand is thought to be a feldspathic igneous rock, inasmuch as the grassy hill vegetation is much more luxuriant than that of the table lands on the borders, making an ideal cattle-grazing area.

At frequent intervals in this sand-hill area are found flat-bottomed "sinks" in which the grass grows waist-high, and which usually contain a shallow lake of variable extent. These wind-swept bowls from land-locked basins collect the surface drainage of a small area, from 1 to 10 sq. mi., infrequently more.

The yearly precipitation of this region is from 15 to 18 in., while the evaporation is probably four times greater. It will thus be seen that the superficial area of any lake will be subjected to extreme fluctuation, increasing through an open winter and spring, and decreasing through the hot summer. The saline content of the waters of each lake will vary from that of its neighbors, not only on account of its size, age and depth, but from month to month, depending upon whether the lake is full or nearly dry. Some of the lakes, whether on account of the large size, youth, or the possession of an underground outlet, are quite fresh. All stages of alkalinity may be observed up to absolute saturation, while the content of potash in the dissolved salts also shows extreme variation, as is illustrated below, from analyses by the U. S. Geological Survey and J. H. Snow of the Potash Products Co.

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Sample No.	Location.	Per Cent. Dry Salts in Sample.	Per Cent. K_2O in Dry Salts.
1	Middle of Jesse Lake	13.55	29.97
2	Sec. 17, T 26, N., R. 43 W	3.21	35.85
3	Sec. 19, T 26, N., R. 44 W small lakes	8.15	15.50
4	Large lake in same section	4.70	31.40
5	Three miles east of Reno	7.20	23.13
6	Sec. 20, T 20 N., R. 44 W	4.56	31.56
7	McCarthy Lake	8.83	30.62
8	Pond ½ mile south of above	8.11	19.82
9	Richardson Lake	7.57	14.44
10	Sec. 1, T, 21 N., R. 46 W	3.33	16.61
11	Thompson Lake	4.30	19.68

The following table gives complete analyses of some of these waters, and shows that the brines carry carbonates and sulphates of the alkalies, the relative proportions being quite fortuitous.

ULTIMATE ANALYSIS

	Sample No.							
	15	12	16	13	23	24	20	18
K_2O	22.48	10.88	8.96	19.98	11.92	28.36	14.50	29.64
Na_2O	24.89	26.87	45.01	11.05	18.90	27.49	38.94	23.82
CO_3	11.82	2.21	29.65	2.80	22.01	20.06	28.40	15.91
HCO_3	6.29	1.39	7.91	3.40	4.98	7.56	12.13	9.20
SO_3	25.01	38.88	2.05	23.56	4.63	12.03	0.44	17.30
NaCl	9.49	19.77	4.33	39.20	37.55	3.97	2.10	2.73
SO_3	.....	.....	2.07	.....	.....	0.52	3.49	1.38

CONVENTIONAL COMBINATIONS

	Sample No.							
	15	12	16	13	23	24	20	18
K_2SO_4	41.63	20.12	4.46	36.98	22.10	27.07	1.03	32.80
K_2CO_3	.....	.....	9.41	.....	.....	20.83	20.39	13.73
Na_2CO_3	28.51	5.33	64.29	6.75	11.99	32.37	52.45	27.87
$NaHCO_3$	9.97	2.20	12.59	5.43	7.34	11.99	19.14	14.63
NaCl	9.49	19.77	7.18	39.20	37.55	6.55	3.46	4.58
Na_2SO_4	10.39	52.53	.....	11.68	21.02	.....	.....	.....
SO_3	.....	.....	2.07	.....	.....	0.52	3.49	1.38
Total salts in per cent. of water	10.61	9.54	8.31	7.86	6.35	4.39	3.70	3.43

The muds underlying the lakes have a corresponding variation as follows:

Sample No.	Location.	Total Salts.	K_2O Content in Salts.
1	Jesse Lake[1]	9.35	25.42
2	Lake near Reno	3.04	14.80
3	Lake near Lakeside	3.58	12.03
4	Sec. 1, T., 21 N., R. 46 W	3.47	13.20
5	Robinson Lake	0.17	26.37
6	Broncho Lake	0.18	21.81
7	School No. 126	1.53	27.79
8	Mayer Lake	0.16	18.25
9	McCarthy Lake	0.55	24.02
10	Hill Lake	0.89	22.49

[1] Analyses 1 to 4 by U. S. Geol. Surv., *Bull.* 540, p. 466. Others by J. H. Snow.

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The alkali crusts from partly or wholly dried-up basins are composed as follows:

Sample No.	Location.	Total Soluble Matter.	K_2O Content, Insoluble.
1	Jesse Lake[1]	34.06	21.00
2	8 miles N. W. of Lakeside	4.62	6.16
3	3½ miles east of Reno	8.51	11.27
4	Crevath Lake	34.05	17.17
5	1 mile northwest of Lakeside	30.85	2.40
6	Jesse Lake	20.25	17.39
7	Cluff	8.97	29.70
8	1½ miles west of Cluff	15.12	12.76

[1] Analyses by U. S. Geol. Surv., *Bull.* 540, p. 466.

Origin of the Lakes.—Prof. Victor Ziegler of the Colorado School of Mines, and Edwin W. Barbour, State Geologist of Nebraska, are agreed upon the main facts as to the formation of the lakes and the origin of their potash content, and their explanations are endorsed by other investigators, albeit not unanimously. Prof. Ziegler says:

An examination of some of the lakes shows that they are underlain by hard pan, buff to dark in color and marly in nature. This serves as a basin and prevents the loss of water by seepage into the loose sands beneath. In other cases, muds, rich in organic matter, which form the bottom of the lake, are apparently impervious enough to serve at least as temporary retainers of water.

From my observations I am inclined to believe that we can recognize distinct stages in the developments of these lakes depending on the general age of the scoop basins in which they occur. When a basin is first formed, the drainage after rains, or as a result of melting snow, is quickly taken up by porous sands on the floor of the valley. Of necessity, such drainage carries into the valley a certain amount of finer sands and such silt as may be present on the hills. This, of course, serves as a packing for the interstices of the sands on the valley floor, making them less pervious. Succeeding inflows of water are not taken up as rapidly and are held some time before dissipation. These intermittent ponds and alkali flats represent youth in the growth of such a lake. As this process continues the silt carried in makes the valley floor less and less pervious and allows the water to stand for longer and longer periods. Finally the point is reached where water is held through the whole season at least in the deeper parts of the basin. Because of their shallowness, even these ponds and lakes will show great variation. These permanent lakes and ponds represent a mature development. Combined wind and water deposition tends to fill these basins; hence the lakes, because of continued shallowing, will again pass through a period of intermittency, representing their old age, until they finally disappear.

It is easy to see how an intermittent lake without outlet will rapidly become "brackish," and Hance, in *Bulletin* 540 of the U. S. Geological Survey calls attention to the fact that vegetable ash, resulting either from burning or from decomposition, contains potash as a far more important constituent than soda. This is especially true of grasses. In the case of these lakes, solubles may be concentrated by surface drainage, or by

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the light fine ash blown into the basins by prevailing winds. Wind concentration is thought by some to be especially important, since the waters and muds of the lake bottoms appear to average somewhat higher in potash toward their eastern edges. This is very striking in some cases, notably Jesse Lake, where the eastern half has been dammed off and all pumping done from that portion.

While the leaching of wood ashes may account for the superficial accumulation of salts, it fails to explain the local presence of more than one sheet of alkali ground water, separated by dry strata. While admitting that this origin of these waters is not yet definitely settled, some geologists who have spent much time in the area attribute the bulk of the potash content of the waters in the sands to the leaching of the considerable orthoclase feldspar contained not only in the superficial sands but in the underlying strata to a depth of several hundred feet.

The decomposition products of such feldspars would form a water quite similar to the alkaline waters of this region, especially in carbonic-oxide solution.

Mr. Edwin H. Barbour, State Geologist of Nebraska, has issued a "Preliminary Report of the Alkali Resources of Nebraska," in which he recounts the early development of the industry as follows:

Messrs. John Show and Carl Modesitt recognized the commercial possibilities of these lakes and to them belongs the credit of bringing the alkali industry in Nebraska to its present state. Their investigation began in 1910. In 1912 they filed mineral claims on the Jesse Lake and the surrounding government lands, and erected an evaporating tower, a frame structure 32 ft. long, 24 ft. broad and 40 ft. high. In the lower portion gas engines, pumps, a 20,000-gal. storage tank, and the necessary machinery were installed. The upper half comprises a series of lattices and some 20 floors, over which the water was pumped at the rate of 300 gal. per minute. From a series of tests in November, 1912, the evaporation amounted to 1200 lb. an hour for a 10-hr. day, on water containing 6 to 8 per cent. total solids. The circulation continued until the concentration amounted to 10 or 12 per cent. of solids. This "heavy liquor" was then transferred to an open tank and evaporated to dryness by direct heat.

Since building this first simple plant many changes have taken place, and the evaporating tower is used chiefly as a pumping storage station. The "brine," which has a greenish yellow tint, was pumped directly from Jesse Lake through a 2½-in. pipe-line to Hoffland, a distance of 3 miles south, where it emptied into three steel storage tanks, one having a capacity of 10,000 gal. and two of 15,000 gal. From the tanks the "brine" flowed by gravity into concentrating vats or "cookers," each 16 by 12 by 5 ft. deep. When reduced to about 20 per cent. solids, it was pumped into steel finishing vats and brought to a 40-per cent. solution.

The "cookers" were arranged in two sets, the first set of four being for preliminary concentration only. The solution is cascaded through these tanks and heated by submerged steam coils. The crystallizing vats are also steel, but have a false bottom of perforated steel plate. The crystals collect on the steel plate and when they build up to the level of the steam coils, the latter are hoisted out, the mother liquor drained

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and returned to circuit, and the remaining slurry, containing 30 to 40 per cent. moisture, shoveled out by men in high rubber boots and loaded into box cars.

Pumping Plant at Jesse Lake.—Inasmuch as the Potash Products Co., operating at Hoffland, 11 miles east of Alliance, on the Chicago, Burlington & Quincy Railroad, was the pioneer of the field, it is natural that its organizers should pick out the best lake found in the explorations, Jesse Lake, which is probably the richest alkali lake in the whole region, having already produced several million dollars worth of potash. After 3 years' operations, it is also natural that their practice in the recovery of lake waters should represent the furthest advance.

Jesse Lake is a body of water covering some 240 acres of ground, and is located about 3 miles north of Hoffland, in a flat, dune-surrounded basin entirely corresponding to the general description already given. The maximum high water represents a level of some 22 in. The pumpage, amounting to 10,000 to 11,000 gal. per 24 hr., is drawn from about 1500 wells, each sunk a distance of from 13 to 17 ft. to the top of the impervious marl layer underlying the lake bed. The spacing of the walls naturally depends upon the texture of the sands. Fine sands may demand holes as close as 10 ft., while coarser sand may allow an increase up to 25 ft.

The wells are drilled by hand from a small platform above the water-level in the following manner. An auger is worked down through the mud and sand until the sides of the hole start caving, when an 8-in. casing is set upright in the hole. The casing is merely a piece of gas pipe of suitable length, with the lower edge serrated with saw-teeth, 4 in. deep. Further sinking is effected by digging within the casing with a sand-bucket, working the casing down by rotating it with chain tongs. A sand bucket is merely a piece of 4-in. pipe, 4 or 5 ft. long, with a cutting point at the lower edge, the hole closed by a check valve. This is suspended by a bale from a piece of rope, and by means of a simple A-frame derrick is dropped through the casing, burying its cutting edge in the sand at the bottom of the hole. It is drawn up and dropped several times, and when full it is hauled out by hand and the contents dumped from the open top.

When the hole has reached the impervious hard-pan, a 1¼-in. "well point" is lowered to the bottom of the hole, surrounded by coarse sand, the casing withdrawn and a new hole started. The well point is merely a piece of 1¼-in. pipe, plugged at the bottom. A short distance from the bottom, the walls of the pipe are perforated, (or a section of fine-mesh screen set in) for entrance of the sand-free ground water. The well point is usually about 4 ft. long, the top bushed down to a ¾-in. pipe long enough to reach the surface of the lake, where, together with forty or fifty others of like size, it is connected through appropriate tees to a 2-in. pipe leading to a pump.

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There are three suction pumps mounted in small houses in the lake, collecting the brines from some 1500 wells and delivering to a fourth pump-house on shore, where the entire pumpage (10,000 to 11,000 gal. per 24 hr.) is forced through a 5-in. iron pipe-line a distance of 3 miles south to the evaporating plant at Hoffland. The pumps are plunger pumps, belt-connected to electric motors, ranging up to 25 hp. in size. An additional 6-in. wooden line is now under construction.

The varying grades of brine procurable from different locations in this lake are so marked that the Potash Products Co. has built a dam entirely across the lake and is pumping water only from the eastern sands, replenishing surface water during the evaporating season by transferring from the larger western portion. The dam is quite a simple affair, as can readily be imagined from the depth of water, and consists merely of two tight board fences with a little back-fill between.

This description follows the general practice of the other operators of the district, differing, of course, in details. The Nebraska Potash Works Co., with a plant at Antioch, 4 miles east of Hoffland, is pumping 800 tons of water per day through 10 miles of 4-in. steel pipe, laid to a number of lakes in close vicinity of their works, while another company is engaged in the installation of a line of 6-in. wooden pipe leading 10½ miles southeast of Herman Lake, tapping several smaller ones en route, to furnish the Nebraska Potash Works Co. with brine.

The American Potash Co., also with a plant at Antioch, draws its water from a series of 35 lakes, largely located in a tract of land owned by John Krause, some 12 to 14 miles north of the plant. This company has one wood pipe-line, 6 in. in diameter and 14 miles long, and one iron pipe-line, about 5 miles long, fed by eight pumping stations, each containing a duplicate installation of pumps with a capacity of 150 gal. per minute, driven by oil engines of from 15 to 20 hp. This company pumps a large amount of surface water, and depends upon solar evaporation to a certain extent. For instance, their lake called Krause No. 1 has a very large area, 110 acres, and is but 6 in. deep. During the summer time the American company pumps water of desirable potash analysis, testing only 3° Bé., into this natural evaporating pan, and withdraws the same at the other end enriched to 17° Bé. During the warm weather the water of this lake becomes too hot for wading, and the lake evaporates more water than the whole steam plant (1400 hp.). It seems reasonable to suppose that shallow wooden tanks with removable covers could be substituted by companies less favorably circumstanced and enormous quantities of solar energy thus utilized. In fact the American company intends to use solar evaporation as an auxiliary to its steam plant by building four concrete basins adjacent to their plant, each 100 ft. square and 5 ft. deep.

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These will be used as a combined brine storage and concentrator. In the summer time the brine will be pumped through atomizer sprays for evaporation, while in the winter nearly salt-free ice will be harvested.

The Hord Alkali Products Co., with a plant at Lakeside, 9 miles further east of Antioch, is owned by men who also own lands north and south of the Burlington railway to the extent of 100,000 acres. At present they are operating four pipe-lines, from 4 to 8 in. in diameter and of a length up to 8 miles. All their present pumpage is from lakes to the north of their plant, but they own lakes on both sides of the railway, and eventually will be pumping a distance of 25 miles. Their operations are entirely confined to brines from sands, and they so arrange their pumpage that the water coming in averages close to a constant figure, about 5 per cent. solids.

At the outset it should be said that the present practice in Nebraska is merely to evaporate these alkali-bearing waters to dryness, so arranging the pumpage from various lakes that the resulting salts have as high a content of potash as possible. No effort is made to separate the soda from the potash, as the dry salts are shipped directly to fertilizer factories where it is used as such. A minimum of 14 per cent. water-soluble K_2O is demanded by this trade, but the Nebraska producers have no trouble in shipping salts containing 20 to 30 per cent. potash, for which they receive payment on the basis of potash content.

Consequently the potash works are merely evaporating plants, and all operate in the same manner, with minor variations in detail. Many of these variations are not the result of desire, but the necessity of taking the equipment which could be delivered at a reasonable time.

The Nebraska Potash Works Co.'s plants at Antioch may be taken to represent the standard evaporating practice of the field. Brief notes of their pumping plants have already been given. Mr. L. F. Hulen, president of the company, experimented on some leased lakes during the summer of 1916 by building a considerable number of solar pans with wooden floorings 12 by 12 ft. 8 in. deep. The lake water pumped into these boxes was sun-evaporated, and at the end of his campaign he was enabled to ship 80 tons of cake, containing 8 per cent. of K_2O, which he marketed at a price of $3.50 per unit.

Following these experiments, he proceeded with the erection of the present plant of the Nebraska Potash Works Co., which evaporates some 800 tons of water per day, and which was first operated in May, 1917.

The layout of the evaporating plants naturally varies considerably. At the Hord plant where low-grade brine is evaporated, it is of course essential that the greatest care be taken to maintain their evaporating

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units at the highest efficiency. At this plant, where between four and five million pounds of water is evaporated daily, the owners have installed multiple-effect evaporators of four different styles; in fact they put in any modern equipment which could be had quickly.

More variation is exhibited in the methods of drying saturated brine than in any other detail. The intermittent crystallization of the salts in steel pans has already been noted in the description of the early Hoffland practice, but this method was not only very wasteful of labor, but produced a salt containing a large percentage of water, which, of course, increased the freight charges without corresponding advantages.

Some style of rotary kiln (shaped after the fashion of the familiar cement kiln) is now almost exclusively used. These kilns are usually 42 in. in diameter and 45 ft. long, of unlined steel plate, containing numerous longitudinal angle-iron shelves riveted to their interior. The upper end of the kiln receives a stream of the concentrated brine through suitably controlled pipes, and the water is driven out as the material works its way down through the kiln. The kiln is heated by a large fuel-oil torch at the center of the lower end, which is partially stopped by a brick wall built to clear the end of the kiln. As the salts are thrown down they accumulate in small nodules, which are lifted by the angle-iron shelves and repeatedly fall through the current of heated air, at the lower end actually falling through the flame itself. On reaching the lower end the nodules fall through slots in the kiln shell into a conveyor of some kind, whence they are diverted through a disintegrator to the storage bins and then sacked and loaded for shipment. The upper end of the kiln rotates within the round opening of a small dust chamber, discharging its gases through short stacks.

These kilns can produce about one ton of dried salt per hour. One difficulty with them is that the drying salt tends to stick and crust upon the inside of the kiln, requiring continuous and severe hammering to keep it loosened. In order to obviate this labor, wear and expense, the American Potash Company has replaced the angle-iron shelves by four lines of heavy chains, hung loosely at intervals. On passing the low point, these chains scrape the attached salts free and keep the interior of the kiln clean at all times.

The Nebraska Potash Works Co. has devised a more efficient practice. They build a fire-box at the upper end of the kiln, using an oil torch as before. The brine is sprayed into the kiln at the same point, immediately ahead of the oil burner, through an atomizer set in the exact center of the kiln. In this way the finely divided brine is brought into immediate contact with the hottest oil flame, and drying is almost instantaneous. Only about one-third of the salt drops out of the slots at

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the lower end of the kiln, however, and reduces the dust losses to workable proportions; a baffled dust chamber has been built of brick some 15 ft. long, 8 ft. wide and 10 ft. high, to receive the dust-laden gases blowing out the cool end of the kiln. A cyclone dust collector is also built into the flue before the gases are finally discharged into the air. With this arrangement, practically no crushing of the salt is necessary, as it is recovered in a fine enough state to meet the demands of the fertilizer trade.

The Lakeside plant of the Hord Alkali Products Co., on the other hand, was an original, patented process, consisting of a regular, brick-lined cement kiln, 6 ft. in dameter and 50 ft. long, running the temperature at a sufficient point that the product delivered at the lower end is well clinkered. This hot clinker is immediately delivered to the upper end of a small, rotary, cooling kiln, 3 ft. 6 in. in diameter and 25 ft. in length, placed alongside, and there sprayed with saturated brine. The heat of the clinker not only evaporates a very considerable amount of liquor, but is itself granulated by the cold liquid, the product requiring no more crushing than that of the other kilns. The output of this kiln is 150 per cent. higher than those previously described.

In all cases, the dust losses are considerable, as is evidenced by the billowy white smoke rolling from the kiln stacks when in operation. While a large portion of this could easily be recovered by modern treater plants, the sentiment of the managers seems to be that they would rather devote their energy to the crowding through of tons of production rather than the saving of hundreds of pounds of waste. It is too bad that both can not be prosecuted simultaneously, as they are both factors leading to the same object.

Searles Lake

Two plants have been operating on the brines of Searles Lake, the American Trona Corp., which has had a somewhat tragic existence, due, apparently, to lack of scientific guidance, and the Boro Solvay Co., a combination between the Solvay Process Co. and the Pacific Coast Borax Co.

Meager information is at hand as to the activities of the Boro Solvay Co., but it can be assumed that the two companies operate much on the same principles.

The problems involved in handling the brines of Searles Lake are more complex than those of the Nebraska lakes, containing, as they do, a great number of salts, many of them hard to separate from each other. Mr. Alfred de Ropp, Jr., gives an extensive description of the operations, which is quoted in part as follows:

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Searles Lake Basin is a broad, roughly circular valley or depression, 8 to 10 miles from east to west, and 20 to 25 miles from north to south, bordered by the abruptly rising slope of the surrounding ranges. This basin lies between the Argus Range on the west and northwest, and the Slate Range on the east; the latter, a narrow, rocky wall, which divides it from the larger and deeper depressions of the Panamint Valley.

The Searles Lake Basin was, during part of the glacial epoch, occupied by at least one deep lake, whose traces are still so distinct as to be indisputable. The determined elevation of the lowest part of the present salt flat in the main Searles Basin is 1,617.6 ft. above sea-level.

The Owens Lake during a period of former greater water supply overflowed the divide at the south end of its basin and its surplus waters flooded in turn a succession of lower basins, of which Searles Basin was one of the largest. The Owens waters, after passing the Haiwee divide, dropped some 1500 ft. in about 30 miles to Indian Wells Valley, and then spread out in a broad and relatively shallow sheet of water. This, in turn, also overflowed, its waters passing by way of Salt Wells Valley and a rock-cut gorge at the lower end of that valley into the Searles Basin.

Eventually the waters rose in the Searles Basin to such a height that all three of these valleys were submerged in one continuous body of water. The maximum water-level in this basin was clearly determined by the elevation of an outlet pass on the south side of the basin, whence its surplus water flowed into the extreme south end of Panamint Valley.

In the Panamint Basin a history similar in some respects to that of Searles Basin was repeated. The waters rose until the height of the lowest outlet was reached, and as they eventually remained stationary at about the level of that relatively long period, it is presumed that this level was determined by the overflow of its surplus waters.

The most distinctive feature of this desert basin is the immense sheet of solid white salts that lie exposed on its bottom. It is to this salt deposit that the name Searles Lake has been generally applied. So far as known at present, the deposit is unique in this country in the variety of its saline minerals.

The crystal body underlies the surrounding mud flats found along the shores of Searles Lake.

The area of salt crust in the Searles Basin is some 12 sq. mi. in extent, and averages from 65 to 75 ft. in depth. The formation of the crystal body is such that the brine with which it is associated is absolutely free-flowing, and nowhere, even by extended pumping operations, has it been possible to lower the level of the brine in the lake at any one spot to a noticeable extent.

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The main or central salt deposit is a firm but extremely porous bed of salt crystals, so hard and compact that roads are built on it, teams and motor trucks have no difficulty in driving over its surface and even the concrete foundations on the American Trona Corporation's pump-house were laid on the surface of the crystal body.

The first 15 to 20 ft. of the crystal body is composed of cubical halite and will analyze 90 per cent. (or better) NaCl on a dry basis. Below this are alternating and irregular layers of salt, respectively high in trona, a sesquicarbonate of soda, sodium chloride and sodium sulphate. The potash content of these layers is very irregular, layers of potash-bearing crystals having been discovered by various drilling operations, which ran from 14 to 30-odd per cent. potassium chloride. (The average potash content of the crystal body is roughly 4 per cent. potassium chloride.)

In a report made to the American Trona Corp. by Charles S. Lee, it is estimated that the crystal body contains 110,000 million gallons, or 594,000,000 tons of brine. This does not include any incoming waters from either underground or surface sources. This brine will average 4 per cent. potassium chloride. The potash contained in this brine amounts to 23,760,000 tons of potassium chloride.

The average brine pumped by the American Trona Corp. has the composition given in the following table:

	Per Cent.
Na	11.00
K	2.50
Cl	12.50
CO_3	2.65
SO_4	4.65
B	0.35

In view of the process in use, the brine is given the following arbitrary composition based on the values above.

	Per Cent.
NaCl	16.50
Na_2SO_4	6.90
Na_2CO_3	4.70
$Na_2B_4O_7$	1.50
KCl	4.75

Specific gravity, 1.29 at 30° C.

All the CO_2 is figured as normal carbonate, although the brine contains some bicarbonate. This brine is pumped to the plant from a well drilled in the crystal body of Searles Lake. The brine is pumped to storage tanks and from them directly to the evaporators. It passes first through a 16-ft. Manistee vacuum pan, which is used merely as a pre-heater. From this it is pumped to three 22-ft. pans of the same type, which are operated in triple effect.

The pans handle from 200,000 to 250,000 gal. of raw brine and about 100,000 gal. of mother liquor per 24 hours. This total of 300,000 to

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350,000 gal. of liquor is concentrated to about 100,000 gal. of concentrated liquor before being sent to the crystallizing house to cool.

During the boiling, sodium chloride, sodium sulphate and sodium carbonate are salted out. These tailing salts drop to the bottom of the vacuum pans and are removed by salt evaporators of the regular Manistee type. The elevators discharge their salts into waste salt cones from which they are washed away by water.

Machinery is being installed by which 95 per cent. of the potash formerly carried away by these waste salts will be recovered. This will increase the output by some ten tons (or better) of potassium chloride per unit per 24 hours. Operating under the old system this was previously lost to us.

The liquid in the pans is boiled down to the point where potassium chloride begins to salt out, and is then sent to crystallizing vats in this condition at a temperature of 90 to 95° C.

Cooling and crystallization take place in crystallizing vats 54 by 15 by 6 ft. There are 36 such vats in the unit now operating, and the day's run of hot concentrated liquor fills from three to four of these. The vats cool for about 8 days, and the liquor, now nearly at atmospheric temperature, is then drained off.

The crystal crop is shoveled into a traveling box and is carried to a drain floor where it is allowed to lie for about a week before shipment.

The following table gives the average composition of raw brine, concentrated liquor, mother liquor returned to the system, and crude potash salts ready for shipment.

PERCENTAGE COMPOSITION OF RAW MATERIAL AND PRODUCTS

	Raw Brine.	Concentrated Liquor.	Mother Liquor.	Crude Potash Salts.
$Na_2B_4O_7$	1.50	8.81	7.82	10.91
Na_2CO_3	4.70	10.82	10.53	1.70
NaCl	16.50	9.67	9.43	10.93
Na_2SO_4	6.90	2.58	2.08	0.44
H_2O	.....	.....	.....	9.66
Total	34.35	46.75	40.68	99.98
Specific gravity at	1.290	1.384	1.362	.....
Temperature, degrees C	30	38	34	.....

The American Trona Corp. is producing to date some 1800 tons of crude potash salts a month. Additional equipment, such as a nearly completed second unit, together with a 300-ton ice plant for refrigerating purposes and new methods for treating the concentrated liquor, will enable the American Trona Corp. to produce some 4500 tons of potash salts a month, analyzing from 75 to 80 per cent. potassium chloride and containing less than 3.5 per cent. borax as anhydrous sodium tetraborate.

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By the first of 1919 the American Trona Corp. will be producing some 40 to 50 tons of refined borax daily analyzing 99.50 per cent. $Na_2B_4O_7 \cdot 10H_2O$. The company owns some several hundred acres of claims in Trona Reef at the northeast end of Searles Lake. The high-grade trona in these claims amounts roughly to 40,000 tons. Besides this there are 20,000 tons of a lower-grade trona comprised in these claims. The company has built a raised road completely across the lake, connecting the Trona Railroad with its trona claims by a narrow-gage gasoline-operated railroad.

Other Brines.—A saline deposit, known as the Salduro salt marsh, in Utah, covers an area of 125 sq. mi. The salt marsh varies in thickness from 3 to 5 ft., covering a mud of unknown depth containing a brine with a potash concentration of 4.5 per cent. The Solvay Process Co. has established a plant on the salt marsh, extracting potash.

Potash is being recovered in small amounts from the waters of the Great Salt Lake of Utah and from the salt bitterns on the Pacific Coast.

Alunite

There was a time when alunite was looked upon as a readily available source for potash, but so far apparently the impurity of most of the alunite deposits has been the cause of disappointment. One operation at Marysvale, Utah, has been working, and with apparent success. The plant of the Mineral Products Corp. started producing during the latter part of 1918, at the rate of 600 tons of potassium sulphate per month.

Several formulas are given by various authorities to indicate the chemical composition of alunite, a double sulphate of potassium and aluminium, of which the following is representative: $K_2O \cdot 3Al_2O_3 \cdot 4SO_3 \cdot 6H_2O$. This formula appears to be nearly correct, *i.e.*, for the alunite now being worked at the town of Alunite, near Marysvale. Several methods have been proposed for the treatment of an ore of this character for the production of potash, but probably the simplest one is that employed in this plant where the ore is calcined at approximately 1000° C. This drives off water of crystallization and sulphuric acid, leaving the water-soluble potassium sulphate and alumina. Upon leaching and evaporation of the resulting solution, potash is recovered as sulphate, with a very small percentage of soda and some infinitely fine alumina which has passed through the filter cloths.

The alunite from the Mineral Products Corp. mine is of a distinctly crystalline nature and from 96 to 97 per cent. pure alunite. There are other large deposits near by, but they are more nearly amorphous in appearance and carry more silica, which seems to interfere with the calcination and also with the subsequent refining of the alumina.

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The alumina residue, containing any silica present in the ore, is now discarded; but it is planned later to refine and use it. It has been discovered that the silica content may be reduced to less than 0.5 per cent. by calcination with producer gas instead of pulverized coal and separation of the alumina from the silica by flotation. The average silica content of the ore used by the Mineral Products Corp. is 3½ per cent. The loss on ignition is approximately 40 per cent., and the raw ore contains an average of approximately 10 per cent. of K_2O or 18½ per cent. of K_2SO_4. The plant is operated profitably and by reason of improvements and refinements which have gradually been developed, will, it is believed, be able to compete with Germany after the war.

Silicates

The potash recovery from cement kilns has increased and two different means of recovery are being utilized. The electrical precipitation by means of the Cottrell system has proven itself efficacious, although the first cost is high.

Spray and water vapor is being used in a growing number of plants. A very complete recovery of the potash vaporized in the cement kiln is accomplished.

Perhaps exaggerated statements have been made of the potash recoverable from the blast-furnace operations of the country. But there is no doubt but that there is an enormous amount of potash lost in the flue-dust and smoke from the iron industry.

Other silicates such as feldspar, New Jersey greensand and others have all received consideration, but so far most of them have not become of vital importance in the potash situation. The most likely value these silicates will hold will be as raw materials for the cement industries, giving a starting product rich in potash and thus a higher potash yield in the dust.

Kelps

During the early part of the year kelp plants were operating all along the Pacific Coast, recovering all grades of potassium chloride. The most noted of these operations was that of the Hercules Powder Co. at San Diego, Calif., and the Government's experimental plant at Summerville, Santa Barbara County, but, with the signing of the armistice, every one operating on a commercial basis closed down, and the outlook is that, if they should be able to resume operations, a careful study has to be made, not only of all the products that can be produced from the

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kelp, but also a careful investigation as to the habits of the plant constituting the source of the potash.

Wood Ashes

The wood ashes in Michigan and Wisconsin have been a source of potash for many years, but it is only since the war emergency came that an intelligent efficient method of obtaining the salts was developed. With careful operation the potash industry developed in these states gives promise to survive and continue even if foreign potash comes in at comparatively low prices.

Molasses

The distillery slops and sugar-house wastes are being recovered and will continue to be so, turning out a potash product suitable for fertilizers which in its crude state finds a ready market.

Potash in Foreign Countries

Germany.—The German potash industry has suffered in many ways, even if it has availed itself of cheap labor in the shape of war prisoners.

In 1918 deliveries were reported of 1,056,100 metric tons of pure potash, of which 137,500 tons went to foreign countries, as compared with deliveries of 918,450 tons in 1917, of which 155,200 tons went to foreign countries. No details were given as to where these deliveries were made, which under the circumstances might only be a means of not mentioning that the salt had been produced and kept in stock for the purpose of flooding the market when peace should come.

The demoralized conditions existing in Germany since the armistice came have undoubtedly made it necessary practically to close the potash mines.

There is no question but that the Germans, all through the war and since the armistice has been signed, have pinned their faith to their potash resources as a means of bleeding the rest of the world and a means of their recovery at the other peoples' expense of some of the treasure they have expended and will be forced to pay in the shape of indemnities.

Fortunately this will not be the case. Potash is being found in an ever-increasing number of places, often in locations where the German potash trust has tried by foul or fair means to keep the discovery of the valuable salts from becoming generally known.

Alsace.—The potash deposits in Alsace are of renewed interest, since

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they will forever be taken out of the Germans' hands and will be freely developed by the French.

The Alsace potash beds are situated in the south of the province, in the plain bounded on the south by the Jura, on the west by the Vosges and on the east by the Rhine. Recent borings have shown that beds of the same formation are to be found beyond the Rhine. The deposits extend as far as the suburbs of Mulhouse. They consist of two beds, of which the lower, the most important of the two, has an average thickness of 4 meters and occupies an area of about 200 sq. kilometers. It is found at a depth of about 650 to 1000 meters. The upper bed is less important, both in area and thickness; it is fairly regularly parallel to the first and is 15 to 25 meters above it.

The beds are formed for the most part of pure sylvine, or potassium chloride. They are situated below a deposit of rock-salt, which attains a thickness of 240 meters. The upper bed has an average content of 35 per cent. of potassium chloride and the lower one of 30 per cent. The layers are nearly horizontal, which greatly facilitates the working. They are not subject to infiltration of water. The total contents of the two beds is estimated at about 700,980,000 cu. meters, or about 1,472,058,000 tons, the average contents of the salt being 22 per cent. of potash (K_2O). The whole deposit represents therefore more than 300 millions of tons. But the most interesting fact is that the purity of the salt greatly surpasses that of all other known deposits of importance, and is notably very superior to that of Stassfurt. Refining is unnecessary for the sale intended for agriculture.

The first boring was made in 1904, near Wittelsheim, by prospectors working for Jos. Vogt and J. B. Grisez. The object was to look for coal. At 358 meters, they reached beds of salt-rock; the boring was continued to a depth of 1129 meters. Potash-bearing strata were reached without their occurrence being detected. It was only later, in examining samples of a dark red color, that the presence of potash was recognized. Other boring showed that the deposit was of a large extent. The company formed to work the discovery made 165 borings, and began working in the first shaft in 1910. This company, the Gewerkschaft Amelie, has founded affiliated companies in order to profit by the regulations of the German potash cartel, which allows a given output to each center of extraction working of a concession of 1800 hectares (4450 acres). At the end of the same year the German company in Stassfurt, the Deutsche Kaliwerke, recognized the value of the Alsatian beds and, fearing the independent spirit of these competitors, bought enough shares to secure for themselves the control of the Amelie Company. They paid 30,000 marks for shares which had cost their owners 5000. Another group of

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French and Alsatian capitalists founded the Ste. Therese Co. This company obtained a certain number of concessions covering 5000 hectares (12,350 acres), and afterward bought most of the shares in two companies which owned concessions adjacent to their own. The different concessions of the Ste. Therese Co. have just begun to be worked. Two of the shafts have reached the deposit and two are now being sunk. Two other German groups have acquired concessions and are carrying out development work. It may therefore be said that the potash basin of Upper Alsace is divided among four parent groups.

The German Potash Syndicate took care to limit the working of the Alsace deposit and only allowed an output of 5 per cent. of the total German output. In order to safeguard the interests of the powerful shareholders of the mines of northern Germany, the deposit furnishing the richer product and the mines which could be most easily and most economically worked were sacrificed to the poorer. In addition, vexatious regulations were made (which seem, however, to have been annulled shortly before the war) enacting, for instance, that Stassfurt should be taken as the basis from which transport charges were to be calculated whatever the destination might be. Thus, for Switzerland or for France, which are 30 kilometers from Mulhouse, the cost of transport was as high as for 600 kilometers as the crow flies between their frontiers and Stassfurt. These tariffs were in force even for the countries adjoining the workings. The State had laid it down as a principle that potash must be considered as a national asset, and must, before everything else, favor the agriculture and industries of Germany.

Spain.—The following interests hold concessions in the Spanish potash field: German Potash Syndicate, the Podine Co., Sociedad General de Industria y Comercio, the Franco-Belge Syndicate and an American syndicate. The work of investigation includes many deep boreholes, the deepest being 880 m. (2885 ft.). The Spanish Government has issued a decree to the effect that certain potash areas are reserved for the State and cannot be claimed by private enterprise.

The Spanish potash area is in the province of Barcelona and near the villages of Suria and Cardona. As in the Alsatian field, these Spanish salts occur in the Oligocene period of the Tertiary formation. The oligocene occurrences near Suria and Cardona form the largest in Cataluna, and occupy a considerable part of the provinces of Barcelona and Lerida.

Great Britain.—A tremendous effort has been made in Great Britain to provide means by which she could become self-dependent as far as her potash needs were concerned. Extensive investigations have been carried out in search for potash and the iron industry seems to have been

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the source from which it has been considered potash most readily can be obtained.

On this account a first factory has been established in Oldbury near Birmingham. The vague information seems to indicate that the industry has had to go through the agonies of childbirth, but in spite of that, promises eventually to supply a considerable tonnage of potash.

Other than this, Great Britain has not shown any marked steps as to relieving the potash needs. Silicates and other potash-bearing minerals have been investigated, though with results similar to those found elsewhere.

Chile.—In the Province of Tarapaca in northern Chile exists a deposit of salts containing large amounts of potash. This is known as the Salae de Pintades, constituting a portion of the Pampa del Tamarugal at an elevation of 3200 ft. above the sea. The area of the saline is approximately 1300 acres. The western boundary is formed by the Coast Range, which at this point consists of high escarpments. On the west it merges into the more elevated parts of the Pampa. Toward the south the saline is broken into a series of basins extending to the salar of Bellavista. The surface is covered by a hard crust of clay and earth mixed with salts of chloride of potassium and sulphate of sodium. The thickness of the crust varies from 2 to 3 ft. Below this is a deposit of crystalline white salt, about 1 ft. thick, followed downward by 6 to 8 in. of sand, containing small amounts of salt. Below this is a deposit of wet clay. This section is characteristic of the entire deposit. The argillaceous material in the crust represents wind-borne dust, which is caught by the moisture present in the basin. The distribution of the potash has been remarkably uniform. The crust contains as a rule from 2 to 3 per cent. of potassium chloride, although at many points the proportion rises to 10 per cent. The white crystalline salts below the crust are usually richer, 10 to 15 per cent. being not uncommon, and rarely falling as low as 4 per cent. Analyses of Enrique Taulis of the School of Agriculture at Santiago give the following average:

	Per Cent.
Moisture (at 110° C.)	5.000
Insoluble	1.324
Chlorine	37.861
Sulphuric anhydride	15.324
Lime (in terms of calcium)	0.272
Carbon dioxide	0.134
Sodium	29.533
Potassium	7.409
Magnesium	Trace
Oxygen (calculated to sulphates)	3.066

Reducing this to the corresponding salts present and comparing the result with the analysis of the carnallite deposits in Germany, the deposit shows some advantages in composition, as seen in the following table.

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	German Carnallite.	Chilean Salar de Pintadas.
Potassium chloride	15.5	
Magnesium sulphate	12.1	
Magnesium chloride	21.5	
Sodium chloride	22.4	
Calcium sulphate	1.9	
Sodium	...	
Insoluble	0.5	
Moisture	26.1	5.00

The absence of salts of magnesium, which are extremely soluble, removes one great difficulty in the purification of the Chilean product, since potassium chloride is relatively insoluble in water between the temperatures of 20° and 30° C., while the sulphate of soda is highly soluble at those temperatures. It is therefore possible to dissolve out the sodium sulphate with but little loss of the KCl in the waste liquors. A recent investigation of this Chilean deposit of potash salt indicates a total quantity of 1,813,833 tons available for treatment, divided into the following grades: salts containing 3 per cent. KCl, 138,956 tons; 6 per cent., 818,797; 9 per cent., 709,513; 12 per cent., 173,826; over 12 per cent., 72,741 tons. The salts represent a concentration in the lower basin of the Pampa del Tamarugal of waters sweeping through, and originating in, the adjacent high Cordillera of the Andes. The source of the potash is in the great masses of liparite, which contain from 3 to 8 per cent. of K_2O. The region is absolutely rainless, so that it is impossible that the salts could have been brought in from the sea, and the constant humidity of the layer of sandy clay proves that the subterranean water reaches the crust by capillarity, where it deposits the salts on evaporation. Although the Pampa is dry and receives no precipitation, there are almost daily storms in the high Cordillera from late December to March, in which the rainfall is heavy. At this period the low basins of the valley fill with water and at times inundate large areas of the pampas. Accordingly there is an inclined water-table, or probably wide channels under the pampas, leading from the main drainage lines in the Andes, and these waters carry the salts dissolved from the decomposing potash-bearing liparite. Samples of water from wells sunk along drainage lines that feed the saline have shown an analysis from 0.191 to 0.750 gm. of K_2O per liter.

Other Countries.—Mexico has been producing small amounts of potassium iodide, but the output is limited and was probably justified only during the war. This is also the case with potash recovered from seaweeds in South Africa and in Japan.

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PRECIOUS STONES

By George Frederick Kunz

While diamonds are worth over four times as much today as they were 25 years ago, this is really quite in line with the general increase of wealth. From 1900 to 1917 the value of the crops produced in the United States increased 425 per cent. and that of the live-stock products 320 per cent., the increased value of both classes of products combined being 388 per cent. This, of course, embraces both an increase of quantity and an increase of price. Within a shorter period, from 1910 to 1918, the prices of the various edible products were increased as much as from 100 to 150 per cent. But the price of diamonds, as articles of luxury, depends primarily on the total augmentation of wealth, and in estimating this due attention must be paid to the increased amount and value of our mineral products.

The following figures calculated from the De Beers reports show that even the rough product at the mines has increased three times in value during the past 30 years, and the enhanced cost of marketing the material and of cutting it has been more than as much again:

VALUE OF DIAMONDS PER CARAT AT MINES

1889	$4.80	1913	$14.22
1895	6.20	1915	10.97
1900	8.25	1917	15.35
1905	11.19	1918	16.48
1910	9.96		

While the increase in value has not been regular, it has been essentially constant.

The great increase in the sale of diamonds is due to the purchases of all classes, for never have the laboring classes had more money, especially in the case of shipyard workmen, among munition workers, in farming districts, at ports of embarkation and debarkation, and notably in the larger cities near which camps were located.

A matter of interest to buyers and sellers of precious stones and jewelry is the new tax laid in the United States on these objects on and after Apr. 1, 1919. The part of Section 905 of the Revenue Act referring to this reads as follows:

That on and after Apr. 1, 1919, there shall be levied, assessed, collected, and paid (in lieu of the tax imposed by sub-division (*e*) of Section

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600 of the Revenue Act of 1917), upon all articles commonly and commercially known as jewelry, whether real or imitation; pearls, precious and semi-precious stones, and imitations thereof; articles made of, or ornamented, mounted or fitted with precious metals or imitations thereof or ivory (not including surgical instruments); watches, clocks, opera glasses, lorgnettes, marine glasses, field glasses, and binoculars; upon any of the above when sold by or for a dealer or his estate for consumption or use, a tax equivalent to 5 per centum of the price for which so sold. This, however, in finished articles is included in the selling price to the consumer. An accurate account of all such sales is kept by the seller.

United States Imports

As shown in the following tables, there was a marked falling off in the imports of diamonds and precious stones into the United States during 1918 as compared with those of the preceding year. However, this decline has been followed by an exceedingly rapid recovery in the early months of 1919, so that there is every indication that the imports for 1919 will exceed those of any previous year.

The recoil from the highwater mark that characterized the returns for 1917 was continued in those for 1918, where the full effects of the heavy war expenses and the greatly increased taxes necessitated thereby were realized in full measure. Yet even so the precious-stone imports were larger by $4,500,000 in 1918 than they had been in 1914, the first year of the European war. Very notable in 1918 was the relative increase (although there was a slight actual decrease) in the imports of uncut as compared with cut diamonds, the uncut diamonds representing but 31 per cent. of the total imports in 1917, while they accounted for 52 per cent. of the 1918 imports. In actual figures the value of the cut diamonds of 1917 was $5,324,988 more than that of the uncut, while in 1918 the conditions were almost exactly reversed, as uncut diamonds worth $4,843,716 more than the cut stones were imported. The change in this aspect of the situation is even more striking if we compare 1918 with 1916, for while the value of the uncut diamonds imported in 1916 was $11,264,704, those registered in 1918 were worth $12,605,526; on the other hand instead of $24,276,882 worth of *cut* diamonds as in 1916, there was only $7,761,810 worth brought in during 1918. This serves to show that the diamond cutters in the United States are securing an even larger share of the diamond industry, and it remains to be seen what will be the effect of the revival of that industry in Belgium and the efforts to develop it in England. However, the exceptionally large diamond imports from March to July, 1919, show a return to the proportion of about 31 per cent. of uncut diamonds.

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IMPORTS OF DIAMONDS AND OTHER PRECIOUS STONES INTO THE UNITED STATES, 1915–1918.

	1915.	1916.	1917.	1918.
Diamonds, glaziers' and engravers', unset and miners', free	.....	$840,735	$1,098,102	$718,397
Diamonds, uncut, dutiable	$7,047,945	11,264,704	13,091,582	12,605,526
Diamonds, cut but not set, dutiable	13,140,548	24,276,882	18,416,570	7,761,810
Pearls and parts of, not strung or set, dutiable	4,309,837	11,972,018	4,898,406	722,981
Other precious stones and bort, dutiable	103,123	257,494	482,224	604,550
Other precious and semi-precious stones, cut, but not set, dutiable	1,021,221	2,143,543	1,752,384	968,094
Imitation precious stones, dutiable	898,656	834,704	1,167,399	890,642
	$26,521,330	$51,590,080	$40,906,667	$24,272,000

IMPORTS OF CUT DIAMONDS AND PEARLS ACCORDING TO THE SOURCE

	Diamonds, cut, but not set, dut.			Pearls, and parts of, not strung, nor set, dut.		
	1916.	1917.	1918.	1916.	1917.	1918.
Imported from:						
France	$2,034,724	$999,564	$170,441	$6,214,056	$3,095,957	$112,580
Netherlands	19,519,572	15,022,899	6,266,319	.....	.....	.....
United Kingdom	2,167,222	2,229,259	1,308,941	5,053,530	1,449,100	376,741
British India	.....	.....	.....	594,519	300,463	150,097
Other Countries	555,364	164,848	16,109	109,913	52,886	83,563
Totals	$24,276,882	$18,416,570	$7,761,810	$11,972,018	$4,898,406	$722,981

In 1918 the notable falling off of the pearl imports is explained by the embargoes laid by Great Britain upon the export of precious stones and pearls from India and other British possessions. A chief reason for this was to prevent the loss of gold by Great Britain that would result from gold payments in Bombay and Calcutta by American dealers, as the precious metal would be drawn from the English reserves; this was more especially to be avoided as the gold exported to India is principally hoarded there, or used for ornamental purposes, and rarely finds its way back to the mother country.

DIAMONDS

TRADE CONDITIONS

The condition of the diamond market in Amsterdam during 1918 differed in certain respects from what it had been in the previous years. The difficulties of the export trade brought about a decrease in exports to the United States, but this was to some extent made good by increased sales to England, France and British India, as well as by an unusual demand from Sweden, Norway and Denmark, to say nothing of more active transactions at home in Holland. Toward the end of the year, the demand from the United States revived and went on increasing. Besides the countries already mentioned, Germany and Russia as well

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became factors in the Amsterdam diamond market, and probably a good part of the diamonds sold in Sweden, Norway, and Denmark eventually found their way to Germany or Russia. The special demand in their case could not well be attributable to economic prosperity, although it must be borne in mind that whatever may have been the hardships endured by many Germans, others profited by the outlays for war materials; but the real cause is believed to be the dread of financial disaster, or in Russia, of wholesale confiscations, and thus easily portable precious stones, which could be carried away on the person, and would command a good price anywhere, had a marked advantage over securities which might become worthless, and over paper money which was rapidly depreciating in value. The able management of the diamond situation by those who control the African output and the marketing in London has thus given very excellent results, by inspiring general confidence in the stability of values in the diamond market.

Japan also is rapidly developing a demand for diamonds, which need not surprise us, since the wealth of that country has increased immensely as a result of the war, in view of the fact that her war expenses were mainly confined to the cost of the expedition against the Germans of the Shantung Peninsula, which did not last more than a few weeks. The demand for diamonds may be considered as a kind of barometer of wealth. Japan's diamond imports for 1918 were valued at $1,059,500, while the worth of the 1917 imports was only $550,000, or little more than half as much as in 1918, and this in spite of the imposition of a heavy import duty.

The removal of the prohibition on the export of unset diamonds from France has recently been decreed by the French Government. It is not, however, believed that a great quantity of French diamonds is available for export. Moreover, in the case of cut diamonds the fact that the older French cut produced stones either quite shallow or else very deep, of types not favored in the United States, would also serve as an impediment. That France should not be buying diamonds to any extent in the Amsterdam market is hardly surprising in view of the financial stringency in the land, and the consequent necessity for economy in the purchase of articles of luxury. The Chamber Syndicale of Paris in 1919 has made repeated efforts to secure a complete relaxation of the restriction in the trade in precious stones and pearls. The power to exercise a very wide discretion in this matter is accorded to the Minister of Commerce, but the unusually large imports for the last quarter of 1918 have made him hesitate to free this trade entirely. On the other hand the president of the Chamber Syndicale has emphasized the fact that France can only export the goods of this type which she imports, and that

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although when stocks have fallen as low as at present, the home demand may absorb a good part of the imports, this will cease to be the case when the stocks have been replenished.

News came to Copenhagen on Apr. 1, 1919, of an order issued in Budapest by the new Hungarian Government, providing that jewels and precious stones the value of which exceeds 2000 crowns should be surrendered without payment to the Communist Government. Those who failed to conform to this order were threatened with the death penalty, a proceeding fully in accord with the Draconian legislation of the Hungarian friends of "liberty or death," a realization of the latter being more probable than that of the former.

Use of Diamonds in Industry

Industrial diamonds, for which the call was so imperative for war purposes, are now being utilized in a great variety of ways, in the making of great tanks and other large objects, and also for smaller products down to fuses. Thus the necessary abandonment of work for munitions and other war implements will probably be in considerable measure offset by the adaptation of many manufactories, forced into being under the stress of the war, as producers of material needed for the rapid expansion of the arts of peace.

The industrial use of diamonds is now so important that it is no cause for surprise to learn that they are utilized in a large factory in the construction of motors. Its particular application here is in regrinding the surfaces of crank shafts, cam shafts, pistons, etc. The diamond, which is set in a small socket at the end of a steel bar, is first covered with grease, and then pressed against the rapidly revolving emery wheel, so that the latter may be reground to a smoothness as nearly absolute as possible. As an indication of the number of diamonds required for this use, the motor factory to which we allude requires $150,000 worth of industrial diamonds annually.

Diamond-cutting

Belgium.—As had been expected, the diamond-cutting industry is rapidly reviving in Antwerp, where it was too firmly rooted not to survive the storms of war. During the occupation of the city by the Germans, most of the cutters and polishers sought refuge in Holland or England, many of them establishing themselves in the Hatton Garden district in London. Now the greater part are eager to return. As is well known, many of them are Jews, and these were not disposed to respond to the tempting offers made by the managers of the Antwerp industry, until they should be assured that they would be recognized as of Jewish nation-

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ality irrespective of the place of their birth. The authorities in Antwerp finally agreed to this. However, Jews of German birth are not as yet admitted, nor are Germans, of course. Everything is to be done to restore the houses of the repatriated to as good state as before the war, and the authorities are taking measures to supply the implements and furnishings the Germans may have carried off. It is expected that before long the regular tide of traffic in diamonds will be resumed, and thus the Saturday night boats from Harwich to Antwerp will soon bear the usual crowd of buyers, who will carry back with them to London, on Monday night, the goods they have bargained for in the interval.

Great Britain.—The newly established diamond-cutting industry in Birmingham, England, shows signs of healthy growth in spite of the not unnatural opposition of Amsterdam and Antwerp. As an answer to the reproach that Birmingham has taken an unfair advantage of the difficulties under which Antwerp has labored because of the German invasion, it should be borne in mind that the beginning of the Birmingham cutting industry dates back before the war. At its outbreak Messrs. Ginder & Ginder had already erected in Hockley Hill a factory especially designed for diamond-cutting, and placed it under the supervision of skilled foreign workers. The material used in its construction, ferroconcrete, was chosen so as to ensure a maximum of rigidity and thus avoid the vibration so greatly detrimental to the delicate operations of diamond-cutting. Boys from the local schools have here received instruction in the art, and those who have been in it for from seven to nine years are already able to take over the task of instructing new-comers. The boys are indentured for a seven-year period, but are paid from the outset whatever they may be able to earn. Some have proved so capable that before the close of their apprenticeship they have earned as much as £4 or £4 10s. a week ($20 or more), while the wage for a fully experienced workman may be as high as £10 a week. As yet there is no idea of competing with the great European centers, but the demand for cut diamonds is so active that there is likely to be work enough for all.[1]

Holland.—Reports from Amsterdam show that diamond-cutting is being actively carried on there, the material coming necessarily from the London market. The Indian demand for brilliants is reawakening, especially as local troubles in India are becoming quieted, and a noteworthy circumstance is that considerable shipments have been made to China, which land is probably destined to become a fair consumer in the future for this class of goods.

South Africa.—The question as to the practicability and the advisability of establishing a diamond-cutting industry in South Africa was

[1] W. T. Gracey, United States Consul at Birmingham, England, *Comm. Rept.*, July 17, 1919.

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brought before the Industries Advisory Board of the Union of South Africa in August, 1918. After giving earnest attention to the various statements, reports and proposals that were made, the members of the Board were impressed with the difficulties of the project, and they were not entirely unanimous in thinking that the present time was particularly favorable for the introduction of the industry. It was believed by many that to promise success the enterprise would require a very large capital, and also the active support of the Government in the beginning in order to contend with the competition of the long-established centers of the diamond-cutting industry in Europe.

Several concrete propositions were made for the establishment of cutting works. One of the applicants asked the privilege of buying, at current market prices, 12,000 carats of diamonds during the first year, increasing this quantity in each succeeding year by 1000 carats a month, until the total annual purchases would be 120,000 carats. An alternative proposal was that the Government should supply the rough stones and take 60 per cent. of the returns on the sale of the cut material. The applicant stated that a master cutter was already in the Union, and he proposed to start his works with 40 Dutch and Belgian cleavers, cutters, and polishers, to be brought from Europe. It was estimated that they would turn out 364 carats of cut-stones weekly from 800 carats of the rough material. This output was believed to represent approximately the present South African demand. As the home or foreign demand increased, additional workers, up to 650, would be brought in, each one of whom was to undertake the training of a South African apprentice.

Two years ago another proposition was made by the proprietor of a small cutting factory in Johannesburg. He asked for a subsidy of £3000 a year for a term of years, and undertook to teach 10 young persons yearly in the various branches of the industry. This applicant suggested that a part of the proceeds of the export tax on diamonds could be properly used in this way for the founding of a home industry. Still another applicant has urged the Government to request the De Beers, New Jagersfontein, and Premier companies to make a definite statement as to their willingness to supply regularly to a bona fide cutting industry, in South Africa, all the rough diamonds it would need, at the same prices as those ruling in London.

The final conclusion of the deliberation was that the establishment of such an industry by Government aid or agency was far too complicated a matter to be decided just at this time.

United States.—The progress of diamond-cutting in the United States is shown by the fact that there are at the present time as many as 600 workers in this branch, for the greater part employed in the vicinity of

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New York City. Their wages run from $50 to $75 a week. This has caused a very considerable increase in the quantity of rough diamonds brought in at the port of New York, as is exhibited in the figures for 1917, compared with 1916. This change became still more accentuated in 1918.

Employment of Crippled Soldiers.—Some further details are available regarding the successful employment of partially crippled soldiers as diamond cutters, which was treated of at some length in our last report.[1] Mr. B. Oppenheim, who has done so much to make the experiment a success, states that he proposed to the Ministry of Pensions that he would train up as many as 2000 disabled men, if the Ministry agreed to pay them for 6 months the training allowance of 27s. 6d. per week which was given to those learning other vocations. After the expiration of the 6 months, Mr. Oppenheim bound himself to pay the men a minimum of £2 a week and to guarantee continuous employment for a period of 3 years. This was not to imply any obligation on the part of the men to remain with him, but left them entirely free to go elsewhere if they considered this to be to their advantage. So many have already applied that the accommodations for training at Brighton will not suffice, and other centres of instruction are to be established at Cambridge, Wrexham, and Fort William. An interesting circumstance is that all the machinery used has been made by disabled men at the workshops connected with the enterprise. In a large number of cases the wages allotted to the trained men have already been increased so that some are able to earn £3 or £3 10s. per week, and it is believed that this will be increased before long to £5 a week, or even more than that.[2] A member of a leading firm of diamond cutters in Birmingham declares that with a little encouragement from the Diamond Syndicate it would be quite possible to have ten or twelve large cutting and polishing establishments in that city within a short time. If the industry were nationally developed in England, work could be provided in this way for 10,000 disabled men.

It is not only in England that energetic attempts are being made to establish diamond-cutting, either with Belgian workers or with maimed soldiers who are being given careful and special training in the art, but Scotland also is enlarging the field, for workshops are about to be erected on the grounds of the Highland Hotel at Fort William by the Ministry of Pensions, and it is expected that they will afford accommodations for some 200 disabled soldiers who are to be trained as diamond-cutters.[3]

It is questionable, however, as to whether men who are over 25 years

[1] MINERAL INDUSTRY, **26**, 583, 584 (1917).
[2] *So. Afr. Min. Jour.*, Dec. 7, 1918, p. 288.
[3] *Watchmaker, Jeweller, Silversmith and Optician*, Jan., 1919, p. 69.

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of age should attempt to learn so difficult a mechanical process, unless they have special qualifications for the work. Probably not more than 10 per cent. could ever become proficient, and the loss in imperfect stones from incompetent workmen would be very great.

Diamond Mining

Brazil.—There is promise of more active work in the Brazilian diamond fields, for quite recently a corporation has been organized in Rio de Janeiro under the title "Companhia Brazileira Diamantifera," for the development of diamond mines at Moribeca and Boa Vista, in the region of Diamantina, State of Minas Geraes. The capital of the new company is set at 3000 contos of réis, equivalent to about $750,000, the number of shares being 150,000, each having a par value of 20,000 réis (the "conto" is 100,000 réis) or in the neighborhood of $5 in United States money. It is said that almost the entire capital is represented by properties owned by the "Syndicato Diamantino."[1]

Congo.—The war failed to check the steady growth of diamond production in the Belgian Congo. From the Kasai diamond field, owned and operated by the Societé International Forestiere et Miniere du Congo, there have been recovered up to the end of 1918 as many as 400,000 carats of diamonds. The growth of production in spite of the war is shown by these returns for the years 1915–1918.

DIAMOND OUTPUT OF THE BELGIAN CONGO

	Carats.		Carats.
1915	48,935	1917	100,000
1916	53,940	1918	164,420

These results were accomplished by the work of 30 white workers and about 3800 natives. Discoveries of new diamantiferous area are constantly made by the Kasai company, and to the northwest of these new workings others have been found by the Lower Congo-Katanga R. R. Co. On the other hand, the war entirely stopped work on the holdings of the Kundelungen Exploitation Co., on which are located many pipes of kimberlite slightly diamantiferous. Neither have any notable results been attained by the Simkat, although diamonds have been found in some of the pipes on these properties. The finding of scattered diamonds in the course of places sluicing is often reported from the northeastern part of the Belgian Congo.[2]

German Southwest Africa.—Following the policy of restriction so consistently carried on in the South African mines by the controlling

[1] Vice-consul Richard P. Momsen, *Comm. Rept.*, Jan. 23, 1919.
[2] "Mining in the Belgian Congo," Sidney H. Ball and Millard K. Shaler. *Eng. Min. Jour.*, Aug. 9, 1919, p. 216

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interests, the output of the former German diamond fields in Southwest Africa, which toward the beginning of the war were producing 100,000 carats monthly, is now cut down to some 30,000 carats monthly. That those fields could have produced more than the largest quantity derived under German management is well known, since the Germans found it necessary to establish a maximum limit, but of course some uncertainty was felt as to the future, since the diamonds have only been found not far from the surface, whither they have been brought by alluvial processes in far distant times.

In the diamond fields of the former German Southwest Africa, the depth of the diamond-bearing layer varies considerably. While commonly but from 4 to 6 in. in depth there are places between Luderitz Bay and Elizabeth Bay where it extends down from 25 to 30 ft. below the surface. The diamond content of gravel from the rich deposits of Idatal in the Pomona district has been as high, in some cases, as 200 carats per cu. meter (1⅓ cu. yd.) and the cost of production has been only 50 cts. per carat. Where, however, the diamonds are more thinly scattered over a wide surface, and the work has to be done in distant places, it has sometimes cost as much as $8.50 per carat, a cost that would notably decrease the profit. Under the German régime about 500 whites and 5000 colored laborers were employed in work. The latter were Cape "boys" or Ovambos. As the Germans did not believe that the diamond fields would continue productive for more than 12 or 15 years longer, the production will not be large enough to seriously compete with the South African mines. That temporarily good results were attained in some quarters under the German management is shown by the fact that the Colonial Mining Co., Ltd., paid during the four years 1910–1913 dividends totaling 112 times the amount of its capital of $24,450. The highest dividend was 3800 per cent. for 1912, and before any dividends could be declared the heavy taxes imposed by the Government had to be met.[1]

The change in ownership of what was formerly German Southwest Africa bids fair to lead to the exploitation of a new source of diamonds. A British company, with liberal financial backing, is said to have been formed to carry on dredging operations on the ocean bed off the coast. It has been known for some time that the diamond deposits extend out beyond the coast line. All the probabilities favor the idea that these submarine deposits are of similar origin with the terrestrial ones in the province, being derived as the latter are from some unidentified source to the eastward, and hence the rumor of the existence of a true "diamond pipe" somewhere beneath the sea appears to lack any satisfactory basis in theory, although of course all theories are subject to the final arbitra-

[1] "Resources of German Southwest Africa," *Comm. Rept.*, June 5, 1919.

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ment of facts. According to the *Board of Trade Journal* the Government is to take 40 per cent. of the proceeds of the work, and arrangements are said to be in a forward state for dredging within a short time. The enterprise is also supported by two well-known South African interests.

Rhodesia.—The official report of the diamond output of Rhodesia for the years 1913–1917 shows that the amount still continues to be small. The diamonds are almost exclusively from gem-bearing gravel of the Somabula Forest.[1]

Year.	Weight in Carats.	Value in Pounds, Sterling.	Value in Dollars.	Value per Carat.
1913	706	3,645	$17,739	$25.13
1914	1,004	3,985	19,393	19.31
1915	272	1,016	4,944	18.18
1916	1,021	5,331	25,943	25.41
1917	619	2,991	14,556	23.51
Total	3,622	16,968	$82,575	$22.80

Union of South Africa.—There was a slight decrease in the diamond production of South Africa in 1918, as compared with 1917, when the reaction from the check given by the war was more decided. In 1918 the weight of the diamonds taken from the mines was 2,537,360 carats, having a value of $35,574,335, while in 1917 the production was 2,902,416 carats worth $38,569,050. This still shows an increase over 1916, the first year of the improved conditions, when 2,346,330 carats were taken out, valued at $27,132,893. The value per carat rose progressively in these years, as follows: 1916, $11.37; 1917, $12.93; 1918, $14.02. The higher prices secured thus served, in part, to offset the smaller output for 1918.

The renewed prosperity of the De Beers mines is shown to have maintained the high standard revealed in the report for the year ending June 30, 1917. In the Thirtieth Report, that for the year ending June 30, 1918, the value of the diamonds sold in the year, plus the increase of stocks at cost of production, is given as £4,327,648 ($21,060,502 at normal exchange). This compares with £4,629,772 ($22,523,837) for 1917, the apparent slight decrease being practically negligible. The undistributed balance on June 30, 1917, was £1,850,861, of which £715,579 represented unsold diamonds in stock at that date. From this total balance the sum of £1,135,277 was appropriated for the stabilization of the diamond trade, through investments in other diamond mining companies and in kindred interests. A further sum of £441,249 was set aside for this purpose from the balance of revenue for the year, making in all £1,576,531 ($7,672,188 at normal exchange). Adding to the

[1] *Bull. Imperial Inst.*, p. 456.

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resultant balance of £715,583, the revenue from diamonds sold, plus increased value of stocks, and an additional amount of £351,901 for interest and dividends on investments, etc., a total of £5,395,133 ($26,248,815) was reached, from which was deducted £1,223,935 for productive mining expenditure, and £548,834 for maintenance of mines and floors temporarily shut down, expenditure on farms, charges, etc., interest in debentures and on capital of leased companies, and sinking fund toward repayment of debentures, and, finally, £135,266 for expenditures consequent to the war, such as salaries and wages of employees on active service, war bonus to all employees, donations of war funds, etc. This left a balance of £3,487,098 ($16,969,963). This sum was distributed as follows: £267,517 as payment of income tax to the Union of South Africa; £441,249, as noted above, for the stabilization of the diamond trade; £740,000 for dividends on the preferred shares, after the deduction of the dividend tax; £1,250,000 for dividends and bonus on deferred (common) shares; the remaining £788,332 being carried as balance to the ensuing year. Of this amount £746,654 was entered on Suspense Profit Account, as representing value of diamonds unsold June 30, 1918, and £41,677 as unappropriated balance. It is interesting to note that the Suspense Account includes "Participation in South-west Africa Diamonds unrealized 30th June, 1917." This, of course, refers to diamonds extracted from the former German mining fields in Southwestern Africa.

The General Reserve Fund was reduced by £96,079 expended in increasing the stocks of blue ground, and now stands at £1,605,086 ($7,814,071). On the other hand the Redemption Fund for the De Beers Four-and-a half Per Cents was increased £498,944. Both of these funds are invested in securities which are estimated at market prices of June 30, 1918. The special reserve fund for the stabiliment of the diamond trade is invested in the shares of other diamond-mining companies and related interests.

In the course of the year the company declared two dividends, each of 20 per cent., on the preferred shares, 40 per cent. in all. On the deferred (common) shares, two 20-per cent. dividends were also declared, as well as a bonus of 10 per cent. on each share, making a total distribution of 50 per cent. on this stock.

The stock of blue ground and lumps on the floors on June 30, 1918, is given as follows in the report.

	Loads.
De Beers	48,396
Wesselton mine	3,012,570
Bultfontein mine	3,220,808
Dutoitspan	2,795,493
Total	9,077,267

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The value of this blue ground is set at £1,295,438 ($6,304,149).

By the death on Sept. 1, 1918, of Mr. Francis Oats, for the past ten years Chairman of the De Beers Co., it has been deprived of the services of one who has devoted himself long and faithfully to it. His sterling judgment, based on protracted experience in the diamond field, made him an almost invaluable aid to the company, and his advice and counsel were always sought for when any momentous decision was to be made.

The quick rebound of production in the De Beers mines succeeding to the rapid decline in the first years of the war is brought out very distinctly in the figures for the years from 1913 to 1918, the successive years ending June 30:

DE BEERS AND KIMBERLY MINES

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Selling Value per Carat.
1913–1914	None	75,815	27,346½	80s. 10.21d.
1914–1915	None	None	83	None
1915–1916	None	None	38½	None
1916–1917	None	None	41	None
1917–1918	None	None	315¾	None
WESSELTON MINE				
1913–1914	2,373,522	2,083,352	593,305	45s. 7.62d.
1914–1915	217,483	219,276	56,359¼	37s. 7.13d.
1915–1916	43,586	885,334	227,914¼	44s. 2.31d.
1916–1917	1,814,393	1,669,104	445,665¾	53s. 9.27d.
1917–1918	2,065,620	1,805,436	487,828¼	54s. 9.76d.
BULTFONTEIN MINE				
1913–1914	2,279,838	2,069,552	785,510¾	40s. 10.47d.
1914–1915	256,950	214,522	76,084	33s. 6.86d.
1915–1916	60,997	864,052	342,676½	39s. 11.09d.
1916–1917	2,092,267	1,761,756	675,401¾	46s. 11d.
1917–1918	2,328,615	1,859,531	646,927½	49s. 9.62d.
DUTOITSPAN MINE				
1913–1914	2,513,469	2,412,679	497,459	84s. 0.9d.
1914–1915	264,039	260,024	55,609¾	68s. 6.25d.
1915–1916	None	108,597	20,740¼	91s. 0.26d.
1916–1917	135,650	1,927,335	377,571½	106s. 11.93d.
1917–1918	2,200,000	2,178,132	422,657¾	108s. 6.22d.
GRAND TOTALS FOR ALL MINES				
1913–1914	7,166,829	6,641,398	1,903,621¼	
1914–1915	738,472	693,822	188,136	
1915–1916	104,583	1,857,983	591,369½	
1916–1917	4,042,310	5,358,195	1,498,679¾	
1917–1918	6,595,078	5,843,099	1,557,729½	
1913–1918	18,647,272	20,394,497	5,739,535¾	

Considerable development work was done in the Wesselton mine during the year. The Main Rock Tunnel on the 1600-ft. level was

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completed. The total length from No. 2 Main Rock Shaft to No. 7 Rock Prospect Shaft is 1420 ft. No. 7 Rock Prospect Shaft, from the 980-ft. level to the 1600-ft. level was holed in December, 1917; its total depth is 628 ft. A water shaft from the surface to the water tunnels was also completed, this having a depth of 130 ft.

The following table gives the number of carats per 100 loads, the value per load and the number of loads of blue ground on the floors of the De Beers mines at the close of the fiscal years 1913–1918, each year ending June 30:

	Carats per 100 Loads.	Value per Load.	Loads of Blue Ground on the Floor at Close of Year.
DE BEERS MINE			
1913–1914	36	29s. 1.28d.	48,396
1914–1915	.....	.....	48,396
1915–1916	.....	.....	48,396
1916–1917	.....	.....	48,396
1917–1918	.....	.....	48,396
WESSELTON MINE			
1913–1914	28	12s. 9.33d.	3,450,638
1914–1915	26	9s. 9.29d.	3,448,845
1915–1916	26	11s. 5.8d.	2,607,097
1916–1917	27	14s. 6.22d.	2,752,386
1917–1918	27	14s. 9.59d.	3,012,570
BULTFONTEIN MINE			
1913–1914	38	15s. 6.38d.	3,095,893
1914–1915	35	11s. 9d.	3,138,321
1915–1916	40	15s. 11.6d.	2,335,266
1916–1917	38	17s. 9.94d.	2,665,777
1917–1918	35	17s. 5.16d.	3,134,861
DUTOITSPAN MINE			
1913–1914	21	17s. 7.87d.	4,358,185
1914–1915	20	13s. 8.45d.	4,341,900
1915–1916	19	17s. 3.48d.	4,233,303
1916–1917	19	20s. 3.94d.	2,411,618
1917–1918	19	20s. 7.42d.	2,434,329

Thus the quantity of the blue ground on the floors of these mines, June 30, 1918, amounted to 8,630,156 loads, against 7,878,177 loads in June 30, 1917, an increase of 751,979 loads during the year, and showing an excess of loads hoisted over loads washed.

The blue ground in sight in these mines on June 30, 1918, is thus reported:

Mine.	Number of Loads.
De Beers, above 2040-ft. level	2,750,000
Kimberley, above 3520-ft. level	2,000,000
Wesselton, above 980-ft. level	11,000,000
Bultfontein, above 1000-ft. level	7,000,000
Dutoitspan, above 750-ft. level	12,000,000
	34,750,000

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This is a decrease of 4,100,000 loads from the corresponding figures of the previous year.

Following are the estimated quantities at lower levels:

Mine.	Number of Loads.
Wesselton, between 880-ft. and 1500-ft. levels	22,000,000
Bultfontein, between 1000-ft. and 1600-ft. levels	22,000,000
Dutoitspan between 750-ft. and 1300-ft. levels	25,000,000
	69,000,000

These estimates are unchanged from last year.

The values per 100 loads of blue ground show a slight decrease for Bultfontein. On the other hand the average selling price per carat is higher for all three of these mines, that for Dutoitspan (108s. 6.22d., equal to $26.08 at normal exchange) being the highest average ever recorded in the De Beers mines.

These figures give the cost of production per load of blue ground, the value per load, and the profit per load in the three De Beers Mines worked in 1917 and 1918.

	Cost of Production per Load.	Value per Load.	Profit per Load.
1917.			
Wesselton	4s. 9.959d.	14s. 6.22d.	9s. 8.261d.
Bultfontein	3s. 9.851d.	17s. 9.94d.	14s. 0.084d.
Dutoitspan	6s. 1.366d.	20s. 3.94d.	14s. 2.574d.
1918.			
Wesselton	4s. 10.94d.	14s. 9.59d.	9s. 10.65d.
Bultfontein	3s. 11.61d.	17s. 5.16d.	13s. 5.55d.
Dutoitspan	3s. 8.8d.	20s. 7.42d.	16s. 10.62d.

Here the only notable change is the great reduction in cost of production for Dutoitspan, entailing a corresponding increase in profit per load.

During the 10-year period from June 30, 1908, to June 30, 1918, the following quantities of blue ground were hoisted and washed from the De Beers mines, yielding the number of carats mentioned; the annual average is also given:

	1908–1918.	Annual Average.
Loads of blue ground hoisted	50,744,568	5,074,457
Loads of blue ground washed	52,018,061	5,201,806
Carats of diamonds produced	15,807,856½	1,580,786
Value of product in dollars	$198,472,897	$19,847,290

The value of the 1918 product in dollars at normal exchange would be $25,192,281, or more than $5,000,000 over the 10-year average. As the carat product of the year was a little below the average (1,557,729¼ as compared with an average 1,580,786) this gives an excellent indication of the notable rise in diamond values at the present time.

At the 30th annual meeting of the shareholders of the De Beers

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Consolidated Mines, Ltd., held on Dec. 13, 1918, the chairman, Colonel Sir David Harris, thus summed up the results achieved in the main properties controlled by the company, and the general condition of the markets:

"During the year under review the diamond market was firm, and prices have advanced. The total number of carats produced by the three largest concerns—De Beers, Premier and Jagersfontein companies—did not total in the aggregate the average annual quantity put on the market by these companies during the three years preceding the war, for the reason that the world was not prepared to purchase the quantity exported in former times. I may say, it is a source of great satisfaction, if not surprise, that the market absorbed the large amount it did, considering the devastation of Belgium and Northern France, the condition of Russia and other States, and the demoralization of the cutting and polishing industry in Antwerp, which was the seat of an enormous diamond trade, and which center will, I feel confident, in the near future resume its great industrial activities. America, as usual, has been our best customer, and we are not only grateful to this great Republic for putting the finishing touches to the ghastly war, but for her continued large purchases of gems, the production of which provides employment for many thousands of human beings, and gives an impetus to an industry of great importance to the Union of South Africa. The stability of the diamond market is attributable to one circumstance, and to one circumstance only, the policy of regulating rates to the demand, and to this fact we owe the present gratifying condition and position of the industry and the confidence established throughout the whole trade."

An exceptionally fine, blue-white diamond, weighing 388¼ carats was found in January, 1919, at the Jagersfontein mine, Orange River Colony. Jagersfontein is already credited with the great Excelsior diamond of 995.21 metric carats (969½ of the older carats). The "Jubilee" diamond found in South Africa in 1895 was also considerably larger, weighing in the rough 650.81 metric carats. After having been cut as a brilliant, the weight was reduced to 245.19 metric carats (239 of the older carats). It has been recently reported that this diamond was sold to a Paris house for the sum of £45,000, or about $220,000 at normal exchange.

The finding of an amber-colored diamond in the Dutoitspan mine of the De Beers Co. was reported in October, 1917. It had the unusual weight of 442¼ carats, and was stated to have been the finest and most valuable diamond ever found in the region of Griqualand West. While not approaching in weight that of the Cullinan or the Excelsior diamonds, the find is well worthy of being permanently registered.

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The Premier Mine directors have continued the policy so successfully pursued in the past, and the results as chronicled in the last report, that for the year ended Oct. 31, 1918, testify to the excellence of their management. The diamonds sold yielded £1,203,904, and the diamond stock was reduced in value to £5362. After deducting £505,379 for mine expenses, £14,240 for directors' and auditors' fees, and £19,012 for administrative expenses, the sum of £670,264 was credited to Expenditure and Revenue Account No. 2. This amount, less £3190 for general equipment, gave £667,074 as the balance of realized profits, of which the 60-per cent. share due the Union Government amounted to £400,244, the remaining 40 per cent., or £266,830, being transferred to Stockholders' Appropriation Account. Out of this were declared two preference dividends of 6s. 3d. per share, each amounting, less Union dividend tax of 7½ per cent., to £46,250, and two deferred dividends of £80,000 each, or 5s. per share. The South African Income Tax was £12,191 and the 7½-per cent. Dividend Tax £21,377.

At the annual meeting held Feb. 28, 1919, the chairman, Sir M. Cullman, made an earnest protest against the imposition of an export tax upon the rough stones. He called attention to the fact that the Government already absorbs 60 per cent. of any increase in value of the Premier diamonds, and thinks it to be not a little hard that a part of the 40-per cent. share of the increase which the company now has should be made the subject of an additional impost.

The Premier Co. gave in its 16th Annual Report the following details of the operations in the mine from the outset to Oct. 31, 1918, to which have been added here the profit per load:

Year Ended Oct. 31.	No. of Loads Washed.	No. of Carats Found.	Value of Diamonds.	Yield Per Load in Carats.	Value Per Carat.	Value Per Load.	Cost of Production Per Load.	Profit Per Load.
			£		s. d.	s. d.	s. d.	s. d.
1903	76,931	99,208¼	137,435	1.290	27 8.50	35 6.70	4 7.20	30 11.50
1904	939,265	749,653½	866,030	0.798	23 1.20	18 5.30	2 7.62	15 9.68
1905	1,388,071	845,652	994,687	0.609	23 6.29	14 3.98	3 3.44	11 0.55
1906	2,988,471	899,746	1,277,740	0.301	28 4.82	8 6.61	3 5.71	5 0.90
1907	6,538,669	1,889,986¾	1,702,631	0.290	18 0.20	5 2.49	2 4.14	2 10.35
1908	8,058,844	2,078,825¼	1,536,720	0.258	14 9.40	3 9.75	1 10.24	1 11.51
1909	7,517,793	1,872,136½	1,172,379	0.249	12 6.29	3 1.43	1 11.42	1 2.01
1910	9,331,882	2,145,832¾	1,496,641	0.230	13 11.39	3 2.49	2 0.56	1 1.93
1911	8,325,272	1,774,206	1,433,971	0.213	16 1.97	3 5.34	2 2.02	1 3.32
1912	9,707,098	1,992,474	2,004,942	0.205	20 1.50	4 1.57	2 4.79	1 8.78
1913	10,434,680	2,107,983	2,336,828	0.202	22 2.05	4 5.74	2 6.67	1 11.07
1914	7,683,943	1,417,755	1,259,643	0.185	17 9.23	3 3.34	2 5.89	9.45
1915	Mining operations suspended.							
1916	1,572,521	419,947	475,856	0.267	22 7.95	6 0.63	2 7.62	3 5.01
1917	4,928,629	906,341	1,198,923	0.184	26 5.48	410.38	2 2.68	2 7.60
1918	4,805,851	851,573	1,203,904	0.177	28 3.29	5 0.12	2 2.89	2 9.73

This gives the following totals for the 16 years:

Number of loads washed	84,297,920
Carats of diamonds found	20,051,320
Value of diamonds	£19,098,330

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The development of the 410-ft. level has been completed, and the blue ground available above that point has been determined to be 37,000,000 loads. Improvements in the prosecution of development work rendered it possible to accomplish this task with less expenditure of labor than would heretofore have been the case.

The blue ground washed during the year came from the following levels:

	Loads.
260-ft. level	526,898
310-ft. level	948,663
360-ft. level	2,745,682
410-ft. level	584,608
Total	4,805,568

While the number of carats of diamonds produced during the year was 54,768 less than in the previous one, and the cost of production per load was a trifle higher, the higher diamond prices more than offset this. A larger output would have been realized had it not been for exceptionally heavy rains in the earlier half of the year and the prevalence of Spanish influenza among the laborers in the later months. Perhaps more important is the falling off in yield per load to 0.177 carats, the lowest point yet reached, although the increased value of diamonds has so far made good for this progressive decrease also.

The Crown Diamond Mining Company of the Orange Free State proposes to double its present capital stock of £125,000; of the additional £125,000, the sum of £20,000 is to be allocated to reserve, and the remaining shares sold at par. This will supply funds for more extensive working, for which there is good promise, as shafts sunk to a depth of 300 ft. from the 140-ft. level reveal additional blue ground.[1]

The following recently formed South African diamond company may be added to the list given in Volume **23**:[2]

The Koodoo Mining Syndicate, Ltd., capital £4500; property rights over 2500 morgen (5275 acres) of the farm Uitkyk, Cape Province; working has already begun.

From the Monteleo Diamonds, Ltd., of South Africa, we have the report that owing to the installation of a new crusher plant, as many as 180 loads of ground can be treated in a day's work. The blue ground now exposed promises well, and a shaft is being sunk to the 200-ft. level, at which point the walls of the mine are to be definitely determined. From April to June, 1918, some 40,000 loads of reef were hauled.[3]

United States (*Arkansas*).—It is anticipated that the United States may become a factor in the diamond output, as the Arkansas Diamond Co. is about to be operated on a somewhat extensive scale.

[1] *So. Afr. Min. Eng. Jour.*, Apr. 5, 1919.
[2] MINERAL INDUSTRY, **23**, 627–643 (1914).
[3] *So. Afr. Min. Jour.*, June 8, 1918.

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The results that have so far been secured in the preparatory working of the deposits are as follows:

Number of Stones.	Weight in Carats.	Average Weight.
2052	793.47	0.387 or $^{25}/_{64}$
110	42.57	(Not weighed, but estimated at about the average.)
2162	836.04	0.387 or $^{25}/_{64}$

Recently a remarkably fine, yellow octahedron, weighing 17.85 carats, has been found, as well as two brown stones of 11.21 and 2.77 carats, respectively, weighing together 13.98 carats, and also six white stones, weighing respectively 6.83, 4.40, 3.38, 2.50 and 1.42 carats, totaling 20.62 carats. These are absolutely perfect and are equal to the finest stones found at the Jagersfontein Mine, or that were ever found in India. The special demand has caused interest in the Arkansas diamond mines and a strong syndicate will finance them for the present.

Other Precious Stones

Australia.—The production in 1918 of sapphires and of corundums used for industrial purposes in Queensland, representing in the main the output of the rich Anakie deposits, is given as follows:[1]

Sapphires.	Value in Pounds, Sterling.	Value in Dollars at Normal Exchange.
Gemstones, blue and fancy stones	11,619	$56,544
Mechanical, corundum and machine stones	2,513	12,230
Estimate of stones sold privately	40	194
	14,172	$68,968

The returns from the Anakie gem-fields show an improvement on last year, although the prices for gem material have ruled a trifle lower. The general tone is good and better prices are expected.

Burma.—The output of gem material in the Rangoon district of Burma for the year 1917 was of much higher value than that of 1916, although the quantity produced was slightly less. This proves that notably higher prices were realized, as appears in the following table, giving quantities and values for the three years 1915, 1916 and 1917, all "war years."

Precious Stone.	No. of Carats.			Value in Dollars.		
	1915.	1916.	1917.	1915.	1916.	1917.
Rubies	167,904	136,785	132,409	$169,748	$174,454	$212,057
Sapphires	39,718	34,100	32,369	6,211	7,018	39,015
Spinels	43,827	38,841	33,422	687	1,085	1,164
	251,449	209,726	198,200	176,646	182,557	252,236

[1] *Queens. Govt. Min. Jour.*, May 15, 1919, p. 112.

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The jade production, which comes from the Myitkyina district in the extreme North of Burma, goes to China, and naturally enough the mining and marketing are in the hands of Chinese. While the quantitative increase in 1917 was not great, the qualitative increase was remarkable, much more of the finest material being produced. A little amber is also found by Chinese near this jade region. The total product of jade of all qualities mined in the 3 years 1915, 1916, and 1917 was 1,303,818 lb.; of amber 8624 lb. was obtained.[1]

The export value of the jade mined in 1917 was £67,502 (about $328,500 at normal exchange) against but £48,926 (about $238,100) in 1916, an increase of $18,576, or over $90,000. The other large contribution of India to the precious-stone market, ruby, sapphire, and the spinels, showed a difference of nearly $70,000 in favor of 1917 over 1916. As a general rule rubies commanded unchanged prices in the London market, although Mogok rubies of superior quality were sold at very high rates. The Indian returns for all classes of stones increased about $160,000 in 1917 over the previous year, and the yield for the year 1918 was double that for 1917, due to the greater demand creating more active search, and the much higher price for which the material sold. This was mainly owing to the unusual demand for the rich-hued jade. The total value of the Burmese jadeite worked into ornaments by the Chinese, when exported from China, totaled over $2,000,000 in the five-year period 1914–18 inclusive.

The rich emerald-green jade, feitsin (jewel jade), imperial jade and jadeite of all shades of green has been in the greatest favor, either in the form of plain beads, or else intricately carved into Chinese forms, generally as pendants, and often with a loose ring of jade cut out of a single piece. These are frequently attached to cords of a green or of some other hue, with a setting of seed-pearls, and strung with beads of jade, or with gold beads. Often there is a simple setting of diamonds encased in platinum. Jade ornaments are highly appreciated all over the world at present, fine necklaces of dark green jewel-jade beads 20 to 40 in. long bringing as much as from $7500 up to $20,000, while for jade pendants the sum is often from $300 to $1500 each.

The Burma Ruby Mines, Ltd., made a good showing in the report for the year ending Feb. 28, 1918, the income and Expenditure Account having at the close a surplus for the 12 months of £3600 16s. 8d. Of this the share of the Government of India was £1080 5s., being 30 per cent. of the whole. Although the number of truck loads of ruby earth washed decreased to 969,919 from 1,181,023 in the previous year, and the cost per load increased to 8.9d. from 6.68 in 1917, there was still a good margin

[1] U. S. Consul Lawrence P. Briggs, Rangoon, Burma, *Comm. Rept.*

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of profit, as the rubies recovered were worth £50,123 12s. as against £40,842 the year before. Of these, the new mines at Kathe must be credited with stones to the value of £23,991, against the £21,860 worth produced in 1917. The total figures show that in spite of the increase of 2.22d. in cost of working, there was an increase of 1.88d. in the excess of value per load over the cost.

In the course of the year the sum of 214,140 rupees was collected from the native miners as royalties, compared with 126,066 rupees in the preceding year. The entire amount was turned over to the Government under the temporary arrangement by the terms of which, in lieu of fixed payment for rent, the Government has been receiving during recent years the actual royalties collected less 10 per cent. The Secretary of State of India has lately agreed to extend this arrangement for another period of 7 years, up to Feb. 28, 1925. On the other hand, the royalties retained by the company in 1914, amounting to £8799 12s., have been handed over to the Government.

The company reports sales of rubies for the year ending Feb. 28, 1919, to the value of £54,598 6s. 8d., as compared with £49,724 14s. 7d. the year before. The native market both in Burma and India was good during the entire year; in London the stock of stones was reduced from £20,405 to £13,115.

Mexico.—Mining for opals in the Queretaro district of Mexico is carried on still in about the same irregular way as it has been already for more than half a century. The opals are for the most part cut out and polished in Queretaro and San Juan del Rio, the establishments for the performance of the work being owned and managed by the local syndicates owning the mines. The stones are found, irregularly distributed, in a reddish-gray spherulitic rhyolite, and the open-quarry working is practised. When the stones have been cut, the less excellent ones are sold to tourists, while the better ones find their way to dealers in Mexico City who dispose of them in foreign markets. Owing to their comparative transparency, Mexican opals often show to the best advantage when given a backing of some dark fabric; for this reason they are sometimes left in the natural matrix, these being known in the trade as "matrix opals."

Persia.—Disturbed conditions in Persia during the war produced a cessation of gem-mining there, so that the supply of turquoise and of lapis lazuli from this source practically ceased. In addition, the interruption of commerce has made it impossible even to bring out any of the stock already on hand. All this conspired to cause a great scarcity of turquoise, as well as of lapis lazuli.

United States.—The Precious Stones Reports of the United States Geological Survey were instituted by George F. Kunz in 1882. The

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totals for the years 1880, 1881 and 1882 were estimated by him, and the figures given for 1882–1905 inclusive are his. From 1906 to 1914, inclusive, the figures are those of Douglas B. Sterrett, and from 1915 to 1918, inclusive, those of Dr. Waldemar T. Schaller.

VALUE OF THE PRODUCTION OF PRECIOUS STONES IN THE UNITED STATES

1880	$100,000	1893	$264,041	1906	$208,000
1881	110,000	1894	108,650	1907	471,300
1882	150,000	1895	113,621	1908	415,063
1883	188,750	1896	97,850	1909	534,280
1884	222,975	1897	130,675	1910	295,797
1885	209,900	1898	160,920	1911	343,692
1886	118,750	1899	186,220	1912	319,722
1887	163,600	1900	231,170	1913	319,454
1888	139,850	1901	289,050	1914	124,651
1889	188,807	1902	328,450	1915	170,431
1890	118,833	1903	307,900	1916	217,793
1891	235,300	1904	324,300	1917	131,012
1892	312,050	1905	326,350	1918	106,523
Total					$8,785,730

This output includes sapphires worth $1,260,663 and rubies valued at $21,170 for 1882–1914, to which is to be added $241,598 for 1915–1917, when both are entered as corundum, making a total for both classes of $1,523,431 for the 37-year period 1882–1918. Diamonds to the value of $29,076 were recovered in this period, most of them since 1906 from the Arkansas field. Of kunzite or hiddenite (variety of spodumene) the value secured was $134,045, while tourmalines furnished $610,795 of the total and turquoises $2,021,702, this being the highest figure credited to any precious stone in the United States, which shared with Persia in the production of this beautiful and favorite gem. The sapphire figures, as estimated, are exceedingly low, as these stones were cut abroad and then returned to this country. They should be increased, probably by 50 per cent.

The following values of precious stones were produced in the United States in 1918: corundum, $42,414; quartz, $15,211; tourmaline, $6206; turquoise, $20,667.

Less precious stones were found in 1918 than in former years. Owing to war conditions, the high cost of labor and the absence of many small producers, less mining was done than ever. The principal discoveries according to districts were as follows:

Oregon.—Quantities of beautiful agates were found in the vicinity of Medford, many of them exceptionally fine moss agates. Then there were also the small, beautiful pebbles found at Tuscarora Beach, Calif., which are extensively purchased by the tourists who visit these regions.

Montana.—Sapphire mining was carried on for the blue stones at Yogo Gulch, Fergus County. The output was still further hampered, owing to war conditions and to the lack of lapidary facilities in France, England and Germany, where many were formerly cut. A great quan-

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tity of the stones from Philipsburg, Granite County, and from the Missouri River district were mined for their industrial qualities—for watch jewels, the bearings of scientific instruments, etc. The value of Montana precious stones, most of which was sapphire, was $47,753, of which about $30,000 represented blue stones for gem purposes.

Nevada.—Large masses of opal, more than $5000 in value, were found in the northern part of Humbolt County. These, in many instances, were an alteration or replacement of wood by opal, the color being dark, almost a petroleum color. They are wonderfully lustrous, but owing to the large water contents frequently crack; nevertheless they are admirable mineral specimens.

Arizona.—From Arizona only a limited amount of garnets, rich ruby-red pyropes, were gathered; all were found on the wind-blown sandy surface.

For optical purposes in connection with the War Department there was a demand for quantities of rock crystals. Unfortunately, very little of value was obtained in the United States, the demand being supplied from Brazil and, to a slight extent, from Madagascar.

California.—A limited amount of kunzite was found in the Pala district, and some crystals of rubellite weighing from 3 to 8 lb. each.

The following figures as to the total gem production in California annually for the period 1900–1917 are presented in "California Mineral Production for 1917," by Walter W. Bradley, Mining Statistician, Sacramento, 1918, p. 93.

Year.	Value.	Year.	Value.	Year.	Value.
1900	$20,500	1906	$497,090	1912	$23,050
1901	40,000	1907	232,642	1913	13,740
1902	162,100	1908	208,950	1914	3,970
1903	110,500	1909	193,700	1915	3,565
1904	136,000	1910	237,475	1916	4,752
1905	148,500	1911	51,824	1917	3,049
				Total	$2,091,407

Maine.—Some very fine rich tourmalines, wonderfully brilliant pale green in color, were found in the Auburn district.

As to the product of gem mining in Maine, $7132 worth of cut gems from this source is reported for 1918. This includes tourmalines, colorless, pink, green and blue-green; beryl, colorless, green, bluish yellow, and very rarely pink (cæsium beryl); topaz; quartz, amethystine, colorless, rose and smoky; and a small amount of amazonite. There were also a few garnets and one gem was cut from a fine purple specimen of apatite from Auburn. Almost all of the material was derived from Oxford, Andros-

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coggin and Sagadahoc counties, and it was obtained by a mere scratching of the surface, being only incidentally revealed in mining for feldspar.[1]

Uruguay.—Prior to the great war a considerable supply of amethysts was derived from Uruguay, the departments of Tacuarombo, Artigas, Salto and Paysandú furnishing the greater part. They generally occur as crystals on the inside of geodes, the latter having usually the appearance of common stones more or less rounded in shape. In a bulletin of the Uruguayan Geological Bureau it is stated that the exports of amethyst for 1909 were between 13,000 and 15,000 lb., and this was an average year. A large agate supply was also taken from the above-named region. In value the amethyst product varied greatly, ranging usually from about 10 cts. a kilo to something over $12 for this quantity, while for exceptionally fine material as much as over $40 a kilo was realized. The German cutting works at Idar and Oberstein absorbed practically the entire supply of amethyst and agate.

In recent years, the output of amethyst and other precious stones from Uruguay has been both small and irregular. Various causes have been assigned for this. That the disturbance of commercial intercourse due to the war has been one of these causes must be admitted, but, from information secured by the American consul at Montevideo, the director of the Uruguay Geological Bureau has been told that the deposits have been to a considerable extent exhausted as far as the best material goes, so that what remains are the stones of the second grade or even lower. How far this represents the actual situation must be the subject of further investigation. As to agate and amethyst, an expert residing at Montevideo states that the finest come from Artigas, near the Brazilian frontier. They are shipped in barrels to Salto, and then transferred to river-boats which bear them to Montevideo. The Uruguayan agates are superior in quality to those found in Europe.

The amethysts of Uruguay are generally larger, and are of a deep violet hue, rivaling those from Auvergne in France, but not as rich and wonderfully brilliant as the Russian amethysts from the Ural region, or those of Ceylon. And yet many are sold as "Siberian" amethysts. It is believed that this beautiful and refined gem will be greatly in demand for mourning wear, in view of the fearful loss of life entailed by the world war. This is said to have been the case after the Franco-Prussian War of 1870–1871.

Venezuela.—The pearl fisheries about Margarita Island, off the coast of Venezuela, South America, were visited in February, 1918, by a most unfavorable phenomenon, locally called "el turbio." This is a contamination of the waters, from some unknown cause, that makes the oysters

[1] *Eng. Min. Jour.*, May 24, 1919.

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sicken and die, thus producing a depopulation of the beds. In order to allow the mollusks time for recuperation so that the beds may be restored to their former state, fishing has been prohibited in the infected district. The economic loss in the year's fisheries was quite considerable, amounting to from 3,000,000 to 4,000,000 bolivars, or from $570,000 to $772,000 of U. S. money.[1]

[1] Homer Brett, U. S. Consul at La Guaira, Venezuela. *Comm. Rept.*, May 29, 1918.

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QUICKSILVER

Mining for quicksilver (mercury) in the United States began in California in 1848, and the total production to the end of 1917 was 2,305,130 flasks, valued at $108,708,078. Large as this sum is it is only about one-ninth of the value of the lead produced in this country to the end of 1915, or about one-sixteenth of the value of the silver, one thirty-third of the value of the copper, or one thirty-fifth of the value of the gold mined prior to 1917. Thus quicksilver mining is a comparatively small industry in this country.

Up to 1882 the mines of California supplied all the quicksilver produced in the United States. Texas, which began production in 1899 with 1000 flasks, now ranks as the second quicksilver-mining State in the Union, with an output of 10,791 flasks in 1917 and 8475 in 1918. Nevada, which now holds third place, began production in 1903, reached its acme with 2550 flasks in 1912, and yielded 997 flasks in 1917, increasing to 1023 in 1918. Oregon, with 388 flasks in 1917 and 673 in 1918, ranks fourth, and much smaller quantities are obtained from Arizona, Idaho, and Washington. From 1903 to 1907 considerable quicksilver was produced in Utah, the annual output from that State amounting to 1133 flasks in 1905, but Utah now produces no quicksilver. In 1918 there was no production from Arizona or Washington.

The world's production of quicksilver in 1917 is estimated at 122,592 flasks, of which the United States produced 36,159 flasks, Italy 29,300 flasks, Spain 25,133 flasks, and Austria-Hungary probably about 27,500 flasks.

The domestic output of quicksilver in 1918, according to statistics compiled by the United States Geological Survey, was 32,883 flasks of 75 lb. each, a total of 2,466,225 lb., valued at the average market price at San Francisco at about $3,808,266. Compared with the output in 1917 of 36,159 flasks, valued at $3,808,266, this shows a decrease in quantity of 3276 flasks, but an increase in value of $55,486.

The productive States were California, Texas, Nevada, Oregon, and Idaho, named in the order of decreasing importance.

A survey of the known quicksilver deposits of the country shows that the deposits, with few exceptions, are not large, that most of them probably do not extend to great depth, and that many of them are decidedly of superficial character. Even if the ore at certain localities does continue to a depth of 1000 ft. or more, some of the deeper orebodies, in consequence of their irregularity and lack of continuity, are likely to

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remain undiscovered. Some of the mines that are at present the most productive have in all probability passed their period of greatest yield, although there is still a possibility that the discovery of new orebodies may restore them temporarily to something like their former activity.

During the last 20 years comparatively few new quicksilver deposits have been found, and only four or five of these have produced more than a few hundred flasks each. Of the total domestic production of 36,159 flasks in 1917 less than 600 flasks came from new mines opened during the war period, and not one of these promises to develop a production of 1000 flasks or more annually. The exploitation of the Terlingua district of Texas represents a notable modern addition to the known quicksilver resources of the country. Other regions capable of as great or greater production may be awaiting discovery, but as years pass the possibility is diminishing, and it is now hardly probable that any other locality with the potential productivity of the Terlingua district will be discovered in the United States.

STATISTICS OF QUICKSILVER IN THE UNITED STATES

Year.	Production.					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1904	28,876	5,336	700	(c)1,204	$1,348,185	21,064	731	$841,108	212	$160
1905	24,655	5,000	1,050	1,045	1,217,652	13,460	458	497,470	2,690	1,710
1906	19,516	4,517	1,276	861	1,035,138	6,455	220	244,299	84	50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	(b)18,860	(g)2,396	.....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	171,653	75,361
1914	11,485	(h)	5,083	536	811,832	1,446	49	70,753	685,605	300,000
1915	14,000	(h)	7,033	716	1,768,225	3,370	115	225,509	421,884	282,852
1916	(b)21,045	(g)8,504	383	1,018	3,768,139	8,880	302	670,475	424,396	515,916
1917	(b)23,938	(g)11,788	433	1,237	3,808,266	10,778	366	998,470	389,487	447,624
1918	(b)22,664	(g)9,495	724	1,119	3,942,301	3,096	105	338,680	361,879	365,930

(a) Reported by the California State Mining Bureau, except as noted. (b) Figures of the U. S. Geological Survey. (c) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (d) Figures collected by MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

Market.[1]—At the beginning of 1918 the price for quicksilver was $115, San Francisco, and $130, New York, the latter market being at a rather large premium owing to the shortage of spot supplies. The deficiency was soon relieved, however, and the New York price declined to $125. During the remainder of 1918 the quotations were pretty steadily $115, San Francisco, and $125, New York, the fluctuations above and below those figures being but trifling.

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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MONTHLY AVERAGE PRICES OF QUICKSILVER
(Per flask of 75 pounds)

Month.	San Francisco.					New York.		
	1914.	1915.	1916.	1917.	1918.	1916.	1917.	1918.
January	$39.25	$51.90	$200.50	$80.20	$115.58	$231.50	$81.04	$126.77
February	39.00	60.00	200.63	116.25	116.96	283.50	120.90	119.89
March	39.00	78.00	223.75	112.50	115.83	213.75	113.30	121.63
April	38.90	77.50	147.50	115.00	115.46	140.38	115.64	121.87
May	39.00	75.00	97.50	105.00	113.30	95.10	105.98	118.97
June	38.60	90.00	73.81	86.20	113.48	73.00	84.34	122.66
July	37.50	95.00	79.90	102.18	116.69	79.80	107.80	126.63
August	80.00	93.75	75.00	111.10	118.33	74.75	115.00	125.56
September	76.25	91.00	75.06	110.90	119.00	75.50	112.21	127.81
October	53.00	92.90	75.80	100.62	119.33	79.40	100.94	127.18
November	55.00	101.50	75.50	100.75	118.91	79.25	102.50	124.91
December	53.10	123.00	78.00	111.65	115.60	80.00	115.90	117.70
Year	49.05	85.80	125.25	104.36	116.54	125.49	106.30	123.46

AVERAGE PRICE OF QUICKSILVER IN SAN FRANCISCO
(Per flask of 75 pounds)

Year.	Price.	Year.	Price.	Year.	Price.
1907	$39.60	1911	$46.01	1915	$85.80
1908	44.17	1912	42.05	1916	125.25
1909	45.45	1913	40.23	1917	104.36
1910	46.51	1914	49.05	1918	116.54

In April the Government made arrangements with the producers for the supply of its requirements at $105, basis San Francisco, the producers delivering supplies pro rata. Otherwise the market was left free. In December the price declined to $115, New York, the San Francisco price remaining at $115.

Costs.—Any attempt to estimate the cost of metal production is likely to be misleading, since conditions vary so much from district to district, while even with identical mining and metallurgical practice and efficiency, the cost per unit varies immensely with the tenor of the ore. F. C. Ransome, in a recently issued Geological Survey publication on quicksilver, has estimated the labor required to produce mercury in American mines during 1917 as follows:

RELATIONS OF QUICKSILVER PRODUCTION TO LABOR IN CALIFORNIA AND TEXAS

	California.		Texas, Three Mines.
	All Mines.	Eight Leading Mines.	
Ore treated, short tons	235,786	203,449	26,802
Quicksilver produced, flasks	23,938	18,581	10,530
Tenor won	0.38	0.34	1.47
Average number of men employed	950	715	253
Man-days of work	310,500	233,689	84,795
Quantity of ore treated per man, short tons	248.1	322.8	105.9
Quantity of ore treated per man-day, short tons	0.75	0.99	0.32
Quicksilver obtained per man annually, flasks	25.1	26.0	41.6
Quicksilver obtained per man-day, flasks	0.077	0.079	0.124

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On this basis he estimates that in 1917 the average cost, including development and amortization, of producing a 75-lb. flask of mercury in California from 0.38-per cent. ore was from $65 to $70. The cost in Texas was lower, due to its average content of 1.43 per cent. Spanish mines in Almaden made $12 quicksilver from 9.04-per cent. ore in 1915. Monte Amiata in Italy produced mercury for about $30 in 1913 from 0.89-per cent. ore, while the pre-war cost at Idria, Austria, was $23 per flask from 0.65-per cent. ore.

Quicksilver in the United States

California.—The production of California in 1918 was 22,644 flasks against 23,938 flasks in 1917, a decrease of 1294 flasks. As usual of late years, the New Idria mine, with which is included the San Carlos mine, yielded nearly half of the total output of the State. Its product was greater than in 1917 and exceeded that of any other year in its history except 1867 and 1868. No other old quicksilver mine in California has so well sustained in recent years a production comparable with that of those early years when quicksilver mining in California was in its prime. Only one other mine in the State, the New Almaden (including the El Senador mine) produced over 2000 flasks in 1918. New Almaden has produced to date about 1,124,100 flasks and in 1865 alone produced 48,138 flasks from ore that yielded 11.3 per cent. of quicksilver. In total production New Idria, with 315,434 flasks to the end of 1918, ranks second, and Oat Hill (Napa Consolidated), with about 140,000 flasks, comes third. The New Guadalupe, Oceanic, Sulphur Bank, Aetna, and Cloverdale mines each produced over 1000 flasks in 1918, and the St. Johns over 500 flasks. Other mines that yielded less than 500 but more than 100 flasks are the Great Eastern, Socrates, Culver-Baer, Helen, Big Chief, Patriquin, and Cuddeback. .

Sulphur Bank nearly trebled its output of the previous year and probably would have made still larger gains were it not for the fact that the high sulphur content of the ore renders furnace treatment and condensation difficult. The Rutherford mine, in Napa County, formerly known as the Bella Union, became productive in 1918 after a period of idleness. A rotary furnace is being put up near by, and this mine should increase its output in 1919. The Big Chief, near Anderson Springs, Lake County, is a new mine, opened on a body of ore that was discovered at the beginning of the year. The ore extracted has been reduced in the retorts of the neighboring Big Injun mine. The Patriquin mine (formerly the Cholame), in Monterey County, after a period of successful operation with retorts, has been for the time abandoned, and the operations of the Patriquin Mining Co. have been transferred to a

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hitherto undeveloped deposit about 2 miles from the 20-ton Scott furnace formerly operated by the Kings Quicksilver Mining Co., in Kings County. To this furnace, which is reported to be in excellent condition, the ore from the new mine is hauled in motor trucks. Prospecting at the Oat Hill mine was carried on during the year, but no quicksilver was produced. The Cloverdale mine, under new management and in spite of a very unsatisfactory furnace, notably increased its output in 1918.[1]

A notable contribution to the subject is Bulletin 78 of the California State Mining Bureau, entitled "Quicksilver Resources of California," by Walter W. Bradley. It is the first work published in 15 years dealing distinctly with quicksilver and its metallurgy and has had only two predecessors in this particular field—G. F. Becker's "Geology of the Quicksilver Deposits of the Pacific Slope" and William Forstner's "Quicksilver Resources of California."

On June 26, 1918, the status of quicksilver in the United States was discussed at a conference held in San Francisco between members of the U. S. Tariff Commission and representatives of the quicksilver producers. The producers expressed the opinion that a protective tariff of at least $35 a flask, in addition to the present 10 per cent. *ad valorem*, will be necessary to protect the American producer from foreign competition.

Texas.—The output of quicksilver in Texas was 8451 flasks, against 10,791 flasks in 1917. The Ellis mine, near McKinney Springs, considerably increased its output, and the Mariposa mine also made a small gain. The output of the Chisos mine, however, declined, and that of the Big Bend showed a still larger falling off. The Big Bend has been nearly exhausted down to the level of the underground water, so that pumping and additional development will be necessary if any considerable output is to be maintained.[2]

During 1918 quicksilver was produced in Texas by the same properties as in the previous years—the Chisos, Mariposa, and Big Bend mines in the Terlingua district, and the Ellis mine, about 40 miles further east. At this last-named mine the ore is treated in retorts designed by the mine superintendent. The retorts are placed on an incline, the ore moving through by gravity. At the other mines the metal has all been extracted by means of Scott furnaces, ranging in capacity from 10 to 50 tons.

The Mariposa mine, which at one time was one of the largest producers in the country, is unique among the mines of Texas in that practically its entire production has been obtained from the surface. The ore occurs in numerous outcropping fissure veins over a wide area. The present management is mining ores considered too low in grade by the original operators in the days of low prices. Prospecting at depth is

[1] U. S. Geol. Surv. [2] U. S. Geol. Surv.

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being carried on. This mine, at the western end of the district, lies in formations that are 700 ft. deep at the Chisos mine, six miles further east, and supposedly about 1300 ft. deep at the Big Bend and Texas Almaden mines, six miles still further east at Study Butte, which is the eastern end of the district so far as developed.

The Texas Almaden is not producing, but both it and the Big Bend mine are being unwatered by joint operations between the lessees of the Texas Almaden Mining Co. and the Study Butte Mining Co., lessees of the Big Bend. These mines have a 50- and a 20-ton furnace, respectively. The ores occur in a series of fissures filled with calcite and cinnabar, and occasional impregnations in an intrusion of rhyolite. The intrusion is 500 ft. thick; it is flat lying and covered by 50 ft. of limestone shale, except at the southern extremity, where it turns sharply upward, extending 250 ft. above the surface and making the Study Butte.

The only active prospect in the district is the property of the Rainbow Mining Co., adjacent to the Chisos mine. The company is sinking a shaft, which is to reach a depth of several hundred feet, before driving a crosscut toward a fault where ore is expected.[1]

Nevada.—Nevada produced about 1044 flasks, the greater part of which was obtained by the Mercury Mining Co., operating near Ione, in Nye County. The remainder came from small mines in Mineral County, particularly in the Pilot Mountains east of Mina and on Mount Montgomery. No output was made by the Goldbanks Quicksilver Co., in Humboldt County. As the production of Nevada in 1917 was 997 flasks, the yield for 1918 shows a small increase.

Oregon.—Oregon produced 702 flasks in 1918, chiefly from the Black Butte mine, but also from the Rainier mine, in Jackson County, which was not in operation in 1917.

Idaho.[2]—The search for quicksilver ore, which was stimulated by the high prices prevailing as a result of the war's demand for the metal, decidedly stimulated interest in the known quicksilver deposits of the Yellow Pine district in Valley County, where activity was inaugurated in 1917, at which time a small reduction furnace was installed, but was not completed until July of 1918. Production amounted to 22 flasks.

The original discoveries of this mineral in this district were made in 1901 and 1902 by Mr. Pringle Smith of Warrens, when he discovered rich cinnibar float on a tributary of Sugar Creek, which was afterward named Cinnabar Creek. This discovery is less than ten miles due west of the present site of the former boom town of Roosevelt, which is now a small mountain lake due to a subsequent landslide.

The Yellow Pine district, formerly in Idaho County, is now near the

[1] W. D. Burcham, *Eng. Min. Jour.*, Jan. 18, 1919.
[2] Annual Report of Robert N. Bell, State Mine Inspector.

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Eastern border of Valley County. It embraces a large area covering tributaries of the East fork of the South fork of Salmon River, and the principal center of activity in quicksilver ore development is seventy miles east of Cascade, a thriving lumber town on the Long Valley branch of the Oregon Short Line Railway. This isolated position is one of the chief drawbacks to the progress of these new discoveries.

Foreign Countries

Australia.—The mercury deposits of importance so far discovered in Queensland are those at Kilkivan in the Burnett District and at Little River in the Cooktown District. Other localities where occurrences of mercury have been reported include Newellton, Montalbion, Dargalong, Gilberton, O.K., Nebo, Monsildale, and Mount Perry, many others also being recorded.

The deposits about Kilkivan are very numerous and are scattered over many square miles of country to the west, southwest and south of the railway station of that name. Between Gold Top to the northwest of Kilkivan and Ten-Mile Camp to the south, a distance of 12 miles, a belt exists which must be at least 4 miles wide and in which there are innumerable occurrences of cinnabar.

The Little River deposits are 30 miles W. S. W. of Laura, the inland terminus of the Cooktown Railway, the mercury being associated with copper.

The deposits at O. K. near the Mitchell River have been prospected in a small way, and an opinion has been expressed that they are worthy of attention. Other than this nothing is known of the occurrences mentioned above except that at Mount Perry a small isolated deposit containing 5 tons of cinnabar was found which yielded on assay 72 per cent. of mercury.

Mercury deposits of some importance occur in New South Wales, other minor occurrences being recorded in Victoria, South Australia and Western Australia. In New South Wales cinnabar has been found in lodes at Pulganbar, Yulgibar, and Ewengar, localities to the northwest of Grafton in the Clarence District, and also at Cudgegong near Rylstone, while at Spring Creek near Bingera it occurs both in lodes and in alluvial deposits.

In Victoria a small quantity of mercury has been obtained at Silver Creek, a branch of the Jamieson River; in South Australia it is found at Willunga, although not in sufficient quantities to be considered of commercial value, while in Western Australia it has been detected in some of the goldfields in gold-bearing ores.[1]

[1] *Queens. Govt. Min. Jour.*, May 15, 1917.

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Austria.—The production of the mines at Idria put Austria third in the production of quicksilver before the war, with about 850 metric tons a year. War consumption has probably increased this production, but no statistics are available.

Austria also possesses a great number of small deposits, but there is production in quantity only at Idria.

Italy.—The old mines around Monte Amiata were worked for cinnabar by the Etruscans and later by the Greeks and Romans. At Morone some mining was carried on in the twelfth and thirteenth centuries. War and pestilence closed the mines and they were reopened only in the middle of the last century. They gained importance but slowly because of the tremendous production of California. From 1860 to 1874 only the Siele works was in operation. One year later the Solforate Schwarsenberg began producing in a small plant which was closed in 1885. Cornacchino produced in 1880, and in 1887 Reto or Monte Buono followed suit. Twelve years later the plant of Abbadia San Salvatore was opened and in the following year took over the abandoned Corte Vecchia. In 1906 the Siele plant opened the deposits of Solforate Roselli, in 1908 those of Petrineri, near Bagni San Philippo, and in 1909 those of Morone, near Selvena.

At present the district of Monte Amiata embraces eight active plants, four in the province of Siena and four in Grosetto, the former furnishing about 90 per cent. of the total production. Production for several years past has been as follows:

1913	100[illegible] metric tons.
1914	1073 metric tons.
1915	985 metric tons.
1916	1093 metric tons.
1917	1071 metric tons.

Spain.—The famous mines of Almaden are owned by the Spanish Government, but the entire product, except such as is needed for local consumption is contracted to the House of Rothschild in London. This contract dates from Jan. 1, 1912, and is effective for 10 years, so it still has less than 3 years to run. In the original contract, 500 flasks annually were reserved for Spanish consumption, but recently this has been extended to 1000 flasks, to take care of the increasing home consumption. All the production beyond this amount goes to London on the Rothschild contract. While Spain is the foremost producer, and this complete control of the Spanish production makes possible the control of the price by controlling the amount of metal in the market, the other producing countries provide a sufficient amount to prevent an absolute monopoly of the market.

No recent statistics of production are available, but the pre-war production was 1500 metric tons per year.

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In addition to the great mines at Almaden, Spain also possesses productive quicksilver deposits in the Asturian province of Oviedo, in Bajodez (Estremadura) and Granada (Andalusia), while the many others, even those of La Creu, have no commercial importance. To complete the list of mercury deposits the following must be mentioned, even though they are only of geological or mineralogical interest: Andra (Santander), in Teruel, Gargantiel (Ciudad Real), Torbiscon (Granada), Cartagena (Murcia), as also Purchena and Cuevas de Vera (Almeria).

Mieres, the center of the Asturian mining industry (the quicksilver mines of the "Union Asturiana" and "El Provenir" or "Pena y Esperanza de Mieres" are situated here) lies on the railroad from Oviedo to Leon. These deposits were worked by the Romans, but have been reopened only since 1840. The ores are impregnations of cinnabar with a little metacinnabar, amalgam, orpiment and realgar, in the carboniferous breccias and quartzites.

The ores of Usagre Bienvenida in Bajadoz province (on the railroad from Merida via Zafra to Sevilla) are richer than those of Mieres. Here the cinnabar is associated with sulphide of copper ores, spathic iron and manganous carbonate, in quartz veins in the crystalline limestones of the Cambrian.

Metallurgy of Quicksilver[1]

The most interesting development in the metallurgy of quicksilver during the year 1918 was the pronounced success of the rotary furnace of the cement-kiln type, as introduced at the New Idria mine by H. W. Gould. The first furnace of this type was installed early in the year, and has been in operation about 9 months, during which time it has produced upward of 1500 flasks of quicksilver. Two others have recently been put in operation, and two more are in course of construction. This type of furnace has also been adopted at the Cloverdale and the Rutherford mine, which latter property is also under the Idria management, and there is no apparent reason why it should not be a metallurgical success at these properties.

During 1918 the U. S. Bureau of Mines, under the direction in California of Dr. L. H. Duschak, continued research work in connection with the metallurgy of quicksilver, and will doubtless publish in the near future a resumé of its operations and conclusions, which should be of great interest to quicksilver operators.

For condensation purposes, Dr. Duschak is inclined to favor a more extensive use of tile pipe to replace largely the brick and wooden condensers heretofore in use in connection with the Scott furnace, which

[1] Murray Innes, *Eng. Min. Jour.*, Jan. 11, 1919.

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seems to be a decided advance, both in the matter of first cost and in simplicity of operation.

In comparing the cement-kiln type of rotary furnace with the Scott type of shelf furnace, one has to consider both the installation and the operating costs, and with the exception of large mines like the New Idria, where dependable power and skilled labor are readily available, the Scott type of furnace appears the more desirable.

In the matter of first cost one must separately consider the furnace and the condenser system, and if the furnace alone is considered there seems little choice under present conditions. In the matter of operating costs, the Scott furnace seems to have an advantage, for the reason that no skilled labor and no power are required, and also because it may be operated with either wood or oil fuel, whereas the rotary has not proved a success except with oil fuel, which is not always available in out-of-the-way places. Judging by results at the Chisos mine, in Texas, and at the Sulphur Bank, in Lake County, Calif., the rotary furnace has not proved satisfactory on ores containing large amount of sulphur nor on ores containing an excessive amount of fines.

The rotary furnace has an advantage in that it will handle wet or damp ores directly without the use of a drier, whereas the Scott furnace does not give perfect satisfaction except when a drier is used. This latter problem has been fairly well solved at the Oat Hill mine, where a small shelf drier containing about ten tons of ore has been superimposed upon a 40-ton Scott furnace, utilizing the waste heat from the burned ore. This drier has so far given perfect satisfaction, and seems to solve the problem at this property.

It is reported that the rotary plant of five furnaces at the New Idria mine has cost (including condensers, and other necessary equipment) about $200,000, and it is expected that it will soon replace not only the concentration plant but the coarse-ore furnaces as well. In a plant of this size, where the cost of skilled labor and dependable power may be distributed over a large tonnage, the installation will doubtless prove satisfactory and economical. On the other hand, the operating costs might be something of a burden at a small mine, as compared with the extreme simplicity of the old-fashioned Scott furnace.

The condensation problem seems to have been fairly well solved, and the research work by the Bureau of Mines has proved that the condensation losses in a carefully managed plant are small. The use of tile pipe condensers is in accord with the best European practice, and should considerably reduce the first cost of a condenser plant as compared with the old system of brick and wood condensers.

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RADIUM

By Robert M. Keeney

The radium market was stronger during 1918 than during any year since 1914. The increased consumption was due to the entry of the United States into the war on a large scale, which resulted in a heavy increase in the consumption of radium for luminous paint. Aside from a universal use of luminous paint on the dials of instruments purchased by the various governments for use on airplanes and naval vessels, practically every soldier of the United States became a user of radium by the purchase of wrist watches all of which had luminous faces on the dials.

It is probable that about 95 per cent. of the radium produced in 1918 was used in luminous paint and only about 5 per cent. for medicinal purposes. Some doctors in this country also sold part of their radium supply to luminous-paint producers. In Europe this practice was common, and it is probable that the permanent radium supply of the world existing several years ago, and held almost entirely by the medical profession, has been reduced in this way by one-half. The price of radium early in 1918 was $100,000 per gram, but toward the end of the year became $125,000 per gram. During the first quarter of 1919 it dropped to $115,000 per gram.

Production

The production of radium in the United States in 1918 is estimated by Dr. R. B. Moore of the United States Bureau of Mines at 21.7 grams, practically all of which was extracted from the carnotite ores of Colorado and Utah. The largest producer was the Standard Chemical Co. of Pittsburgh. C. H. Viol[1] of the Standard Chemical Co. states that this company has produced 37 grams of radium to date, out of a total production in the United States of nearly 56 grams. The Standard Chemical Co. claims to have ore reserves in Colorado which indicate that at least 566 grams can be produced from Colorado carnotite.

Dr. R. B. Moore[2] of the United States Bureau of Mines estimates the total radium production from American carnotite to be 48.3 grams up to January 1, 1918. Allowing for part of the year 1918, which is included in the Viol estimate, these two figures check very closely. However, Dr.

[1] "Radium and Radio-Activity," C. H. Viol, *Chem. Met. Eng.*, Dec. 1, 1918, p. 752.
[2] "Radium," Richard B. Moore, *Bull. Am. Inst. Min. Eng.*, **140**, 1164 (1918); *Trans.*, **60**, 708.

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Moore believes the Colorado and Utah carnotite ores will be exhausted in about 7 years, and that the maximum radium production from this source will not exceed 100 grams.

The Schlesinger Radium Co. of Denver increased its production considerably, and through its subsidiary company, the Cold Light Manufacturing Co., manufactured thousands of dials illuminated with luminous paint for military and naval use. The Chemical Products Co. of Denver passed through the experimental stage at its Denver plant, and at the end of 1918 was making preparations to start commercial production of radium. The Minerals Recovery Co. of Denver purchased the plant of the National Radium Co. late in 1918. A considerable production was made from Colorado ore by the Radium Luminous Metals Corp. of New York. The Radium[1] Ore Sampling Co. started operation of a custom carnotite ore sampling plant at Montrose, Colo. The U. S. Metals[2] Reduction Co. shipped carnotite ore containing 2 per cent. U_3O_8 from Cisco, Utah, to Pittsburgh, Pa. The Carnotite Reduction Co. of Chicago had a small production.

Since 1914, Joachimsthal pitchblende, which had been the main European source of radium, has not been available.[3] Practically all radium extracted by English plants during the war was from ores imported from the United States. Some radium was extracted from the pitchblende ores of Cornwall, one mine alone producing 18,000 mg. of radium bromide in 4 years.

METALLURGY

The most complete contribution on the properties of radium and its extractions which has appeared for several years was made by Dr. Richard B. Moore in a paper presented at the Colorado meeting of the American Institute of Mining Engineers.[4] This paper covers the history of radium, radioactivity, disintegration series, radium ore deposits, metallurgical treatment, ore concentration, the future supply of ore, uses of radium, and mesothorium as a substitute for radium.

Experiments on the extraction of radium from American pitchblende ores by chlorination were made by Mrs. Ray Cable[5] and Herman Schlundt. The uraninite in the pitchblende ores of Gilpin County, Colorado, occurs intimately mixed with iron pyrites. Apparently no satisfactory method of separating the uranium minerals from pyrites by mechanical methods has been devised. Although the extraction of radium from these ores

[1] *Eng. Min. Jour.*, Aug. 24, 1918.
[2] *Eng. Min. Jour.*, Jan. 25, 1919.
[3] "The Radium Industry and Reconstruction," John S. MacArthur, *Min. Jour.*, Jan. 18, 1919, p. 39.
[4] *Bull. Am. Inst. Min. Eng.* **140**, 1164 (1918); *Trans.*, **60**, 708.
[5] "Some Experiments on the Extraction of Radium from American Pitchblende Ores by Chlorination. Mrs. Ray Cable and Herman Schlundt, *Met. Chem. Eng.*, May 1, 1918, p. 460a.

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has been carried out successfully by the U. S. Bureau of Mines, experiments were made on a new method of extraction by direct chlorination of the ore. The process is based on the equation

$$2FeS_2 + 5Cl_2 = 2FeCl_3 + 2S_2Cl_2$$

By conducting the reaction in a stream of chlorine gas the chloride of iron together with the chlorides of uranium appear as a crystalline deposit in the cooler parts of the apparatus, while the sulphur monochloride can be separated as a gas and condensed. The radium is probably converted into chloride, and follows the other chlorides. Water is added and the radium remains in solution. The solution is filtered and the radium is precipitated as radium barium sulphate by addition of barium chloride and sulphuric acid.

A process for the extraction of radium from low-grade Cornwall pitchblende was developed for the British Radium Corporation at a plant near London.[1] Concentrates were boiled in enclosed earthenware vessels with twice their weight of commercial hydrochloric acid. The pitchblende was attacked and rendered soluble, with the formation of uranium chlorides. At the same time ferric and ferrous chloride was formed, which held in solution the radium which had been sulphated by the sulphuric acid in the commercial hydrochloric acid and by the acid produced by partial decomposition of the pyrite present. Boiling was continued for 6 hours, and after settling and filtering the radium was precipitated from the solution with a saturated solution of sodium sulphate and barium chloride solution. During precipitation the solution was agitated with compressed air. The radium-barium sulphate was filtered, and uranium, copper and bismuth precipitated by heating the solution with scrap iron.

The system of radioactive elements was described by I. Hackh.[2] There are three known series of radioactive substances, uranium, thorium and actinium, and these series include about forty substances. In a paper on radium and radioactivity C. H. Viol[3] considers the nature of the atom from the viewpoint obtained by a study of the phenomena of radioactivity, particularly the rays of the radioelements and the *X*-rays.

In U. S. Patent No. 1292341, assigned to the Carnotite Reduction Co., Chicago, Ill., H. N. McCoy patents a process for recovery of radium.

During 1918 the Bureau of Mines Experimental Station of Golden, Colo., determined the solubility of pure radium sulphate as 2.1 mg. per liter at 25° C. both in water and in sulphuric acid up to 50 per cent. acid.[4] Hence radium sulphate is one of the most insoluble salts known. How-

[1] "Extracting Radium and Uranium from Pitchblende," H. Bartly, *Min. Mag.*, Nov., 1918, p. 274.
[2] "System of Radioactive Elements," Ingo W. D. Hackh, *Chem. Met. Eng.*, Dec. 1, 1918, p. 751.
[3] *Chem. Met. Eng.*, Dec. 1, 1918.
[4] Eighth Annual Report of the Director of the Bureau of Mines, 1918.

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ever, the industrial recovery of radium as sulphate does not depend on its solubility alone, but on its passing out of solution, when precipitated with barium, to a much greater degree than its solubility would indicate. Investigation of the laws governing the combination of hydrogen and oxygen under the alpha rays when these gases are mixed with radium emanation is to be extended to other gases. It is believed the results will throw some light on the chemical reactions that take place during electrical discharge, and may be of considerable industrial importance.

Uses

There is a possibility of development of three main uses for radium: first, radiotherapy; second, the manufacture of luminous paint; third, the use of low-grade radium residue as fertilizer.

During the war the progress of radio-therapeutics was much delayed through lack of workers and shortage of material. In war-surgery radium proved useful for preventing adhesions after wounds, and for rendering the scars pliable. In the case of facial wounds this had the effect of greatly lessening disfigurement. It is expected that there will be a large demand for radium by the medical profession in the near future.[1] So important has this application of radium seemed that medical men have advised the United States Government to have all the radium supply of the country conserved for medical purposes alone.

There were no new developments in the manner of use of radium in luminous paint. It is to be regretted that radium is used for this purpose, as the world is losing permanently a rare element which is limited in quantity and can not be replaced in medical work. The United States Bureau of Mines has developed the use of mesothorium as a substitute for radium in the manufacture of luminous paint. It is to be hoped that with this substitute available, legislation will be passed forbidding this use of radium. Mesothorium is found in monazite sand and can be obtained as a by-product in production of thorium nitrate used in incandescent gas mantles. When first extracted it is not in a satisfactory condition for the manufacture of luminous paint, and it is allowed to ripen for about one year before use. During this time the alpha radiation, which is required for luminous paint, becomes sufficiently strong. Radium has a long life, half of it decaying in about 1600 years, but mesothorium has a short life, five or six years being its useful life in luminous paint. The price of mesothorium has varied at from 40 to 60 per cent. of that of radium.

A résumé of research on radioactive luminous materials was made by

[1] *Min. Jour.*, Jan. 18, 1919.

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W. Savage.[1] Interesting radio-photographs of ferro-uranium and uranium steel taken by their own light are contained in this paper.

For several years one company has had upon the market low-grade radium residues for use as fertilizer. Although these fertilizers have been found to stimulate plant growth, the reasons for the results obtained have not been exactly known, and there has been considerable discussion regarding the benefits obtained by use of radium for this purpose. But the practical fact exists that there is a demand for radium residues by agriculturists and horticulturists. Radium fertilizer appears to assist in the assimilation of phosphate and potash and seems to fix the nitrogen.

[1] "Radioactive Luminous Materials." W. Savage, *Chem. Met. Eng.*, Sept. 28, 1918, p. 515.

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SELENIUM AND TELLURIUM

The output of selenium in 1917 was 39,630 lb., valued at $70,000. The producing companies were the American Smelting & Refining Co., the Raritan Copper Works, and the United States Smelting, Refining & Mining Co. Production from four companies in 1918 amounted to 103,700 lb., valued at about $200,000. The value of imports for consumption of selenium and salts of selenium was $59 in 1915, $302 in 1916, $2236 in 1917 and *nil* in 1918.

Most of the selenium produced is a by-product in the electrolytic refining of copper. It is the opinion of metallurgists that if market conditions warranted the domestic production would be greatly increased.[1]

The chief use of selenium during 1918 appears to have been as a decolorizer for glass as well as in the manufacture of ruby glass. The former use was developed through the shortage of suitable grades of manganese, which heretofore has been used to mask the green color imparted by the presence of iron. The demand of glass makers became so great that producers were not able to keep up with the consumption, and the price rose to as high as $3.25 per lb. and remained around this figure throughout the year. During the last quarter, however, there was a slight recession in price, and, at the close of 1918, black powdered amorphous selenium was offered for as low as $2.75 per pound.[2]

A detailed account of the processes involved in the recovery of selenium and tellurium in copper refining is given by Merriss and Binder.[3]

There continues to be little market for tellurium and a correspondingly small production. Only two refiners, the Raritan Copper Works and the United States Smelting, Refining & Mining Co., reported a production in 1917.

Tellurium, like selenium, is a by-product from the electrolytic refining of copper. The domestic production is capable of large expansion if market conditions should warrant, as almost all blister copper contains recoverable quantities of tellurium. Much of this would be saved, if a demand existed, at prices of $1.50 to $2.50 a pound. In 1917 prices at the refinery averaged about $3 a pound.[4]

[1] U. S. Geol. Surv.
[2] *Eng. Min. Jour.*, Jan. 11, 1919.
[3] *Eng. Min. Jour.*, Sept. 7, 1918.
[4] U. S. Geol. Surv.

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SODIUM SALTS

Most of the sodium salts of commerce are made by various chemical processes from one of a few raw materials, and it is in these raw materials that we are interested, rather than the final products. The element is one of the most widely distributed and forms about 2.36 per cent. of the earth as known to man. As a mineral product, it is produced entirely from some of its soluble salts, which in turn were probably ultimately derived from the feldspars or some other of the insoluble sodium-bearing minerals.

Sodium chloride is obtained from sea water, the water of the Great Salt Lake, and many natural brines by simple evaporation. Sodium carbonate and trona are thus obtained from the water of Owens Lake. The brine of Searles Lake yields on complete evaporation sodium chloride, sodium sulphate, sodium carbonate, and sodium borate, but the separation of these salts involves elaborate treatment.

The soluble salts above mentioned, as well as sodium nitrate, are found at or near the surface in dry desert regions, but elsewhere they are carried in solution to the sea. The deposits of sodium nitrate in northern Chile, and that of sodium carbonate at Magadi, British East Africa, are conspicuous instances of accumulation due to favorable geologic and climatic conditions. Many beds of rock salt, found in various regions, have probably originated similarly and have been preserved from solution by impervious covers. Large deposits of salt have been found at depth in Michigan, Kansas, Louisiana, Texas, and New York, in the Stassfurt region in Germany, at Salzburg in Austria, in the Province of Orenberg in southeastern Russia, at Northwich, in Cheshire, England, in Alsace and Lorraine, and in many other regions. From the soluble natural or crude salts are derived all the refined salts described in the following pages.[1]

Sodium Nitrate

The fact that the war was won with Chilean nitrate has served to attract attention to Chile's foremost industry, which has an annual value of about $150,000,000 at the port of shipment, and which brings in an annual revenue to the Chilean Government of about $35,000,000. There

[1] U. S. Geol. Surv.

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is a vast supply of caliche awaiting beneficiation, and large amounts doubtless remain on lands that have been incompletely prospected. To these may be added the enormous tonnages of discarded residue and caliche which will certainly be available for treatment by any improved method that may be adopted. The fact that all this material contains considerable quantities of sodium nitrate will doubtless act as a further incentive for research, in connection with the utilization of modern machinery for extraction purposes.

The veil of secrecy that has so long enveloped the Gibbs process for nitrate treatment was drawn aside to a certain extent during 1918 by the appearance of a brief description of the new process.[1] From this it would seem to embody (1) wet crushing in a ball mill, (2) classification, (3) counter-current treatment of sandy product in Dorr classifiers, and (4) filtration of thickened slime in Oliver filters. Multiple-effect evaporation of the liquor has been adopted. The plant has been in operation for about a year. Results showing the actual recovery of nitrate by the new process and the cost of treatment are being awaited with interest, and it is hoped that they will be published in full detail.

Germany has produced an immense amount of synthetic nitrogen products, and her chemists may be credited with a fairly complete knowledge of the subject. It is significant that, previous to 1914, she absorbed about 25 per cent. of the Chilean output of natural nitrate, and also laid up extensive stocks. The production of the synthetic product in the United States will doubtless encourage the introduction of economies, large-scale working, and improved extraction of nitrate from the Chilean caliche, so that the natural product will be shipped at a cost to compete with the synthetic.[2]

Chile.—An excellent review of the general industrial situation in Chile during the past year is given by D. F. Irvin,[3] from whose report the following is abstracted.

Perhaps the most notable event in the Chilean nitrate industry in the second half of 1918 was the centralization of both purchase and sale of Chilean nitrate by the Allied governments and the Chilean Government.

Since this arrangement has been in force the price has been stationary at 13s. for ordinary, and 13s. 6d. for refined, per Spanish quintal of 101.4 lb. Profit per quintal on this basis is more than normal, but it must be remembered that the present cost of production is, in many cases, higher than the pre-war selling price on the Pacific Coast. New construction work and the maintenance and repairs on all plants have been greatly curtailed during the war, so that the oficinas will doubtless have to make a large outlay in this respect as soon as freights and prices justify the work being started.

[1] "The Advent of Modern Mill Mechanism to Nitrate Leaching." D. F. Irvin, *Eng. Min. Jour.*, June 1, 1918, p. 987.
[2] *Eng. Min. Jour.*, Jan. 11, 1919.
[3] *Eng. Min. Jour.*, Feb. 8, 1919.

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The nitrate needs of the Allies have been met by large-scale contracts, carried out by the joint purchasing board of the Allies, known as the "Nitrate of Soda Executive," through its agency in Chile, and the Chilean Government, acting for the sellers. The purchase of 680,000 tons of nitrate to cover consumption for 1918 was a remarkable transaction.

At the end of the year there was much anxiety as to what would be the amount and price which the Allies would decide upon for their 1919 purchases.

Since hostilities have ceased in Europe the nitrate producers are busily trying to orient themselves, but reliable landmarks are hard to establish. A grave situation in the matter of sea freights may occur through the resolution announced from Washington by the Shipping Board, since the signing of the armistice, to the effect that all vessels are to be withdrawn from the South American trade routes and kept in trans-Atlantic service until sometime next spring.

An interesting and promising step is the recent formation of a scientific and technical society to encourage improvements in technique, and to provide, by means of regular meetings and the publication of a bulletin, for an exchange of views and data on nitrate mining and treatment and to serve, likewise, as an official spokesman for the industry.

This body, known as "El Instituto Cientifico e Industrial del Salitre," was founded by a number of Chilean and English nitrate operators, of well-known business and professional standing, and already has received government recognition. One of its first steps should be to provide authoritative figures for the cost of the most important artificial nitrate substances, per unit of nitrogen, laid down in the business centers of the world.

Alejandro Bertrand, the eminent Chilean chemical engineer, who was until recently the representative of the Chilean Government in connection with nitrate promotion and investigation in Europe, is a member of this body, and has already issued valuable articles, containing authentic data from original sources, on matters concerning artificial nitrate manufacture in Europe. These articles have appeared in the publications of the "Asociación Salitrera de Propaganda."

In June, Germans and German sympathizers in Chile caused an acute though short-lived situation in the nitrate business resulting from an attempt to paralyze activity by legal action in the Chilean courts at a time when the results would have caused the greatest danger to the Allies. Various German firms (owners of oficinas) sued to recover from certain English firms a large amount of fuel oil due them on pre-war contracts, delivery of which had been stopped by the "Trading with the Enemy Act." In default of the oil, the Germans obtained an injunction on the sale or delivery of this to any other persons until they were given what they claimed. However, when the American oil producers allowed it to be known that, unless the injunction was immediately removed, no more American oil would be shipped to Chile, the Chilean Government set aside the court action, and no further trouble was experienced. Local fuel supply in Chile, as in other South American countries, is scarce and of poor quality, so that there is an almost complete dependence on foreign fuel. American and Mexican oil wells supply the bulk of the requirements, especially so far as the nitrate industry is concerned. A stoppage of fuel imports into Chile would have caused a crisis in the nitrate industry and a general financial panic in the rest of the country—a condition that the Chilean Government did not dare to risk.

The statistical situation of the nitrate business may be summarized as follows, according to the data of the "Asociación Salitrera de Propaganda:"

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EXPORTATION OF SODIUM NITRATE FROM CHILE

	Short Tons.
June, 1916, to July, 1917	3,156,051
June, 1917, to July, 1918	3,210,596

At the end of the year there were 140 oficinas at work, including several that had just been completed. Their tonnage of caliche handled daily varies from 250 to 300 to 2500 tons. A common capacity is about 750 to 1000 tons.

Abnormal conditions continue in the vicinity of the German-owned oficinas. The plants are, in most cases, given over to caretakers, and all work is stopped. There is a persistent rumor that the largest nitrate-producing organization—the Cia. de Salitres de Antofagasta—is negotiating for the purchase of the most valuable part of the German holdings, situated in the district of Toco.

Recent construction among oficinas has been limited, though several idle plants were dismantled and re-erected on new ground in other districts. One interesting example of this is the case of oficina Ghyzela, in the Taltal district, which was dismantled and transported by rail, about 350 miles, to Tarapacá and re-erected as oficina Santa Laura. The same company has built oficina Brac, in Tarapaca, and Lina, in Antofagasta. It is interesting to note that the latter two are both owned by Jugo-Slavs. Oficina Cristina, in Aguas Blancas, is a new plant just starting up; and the Du Pont Nitrate Co. began work in December at its new plant at oficina Peña Grande, in Tarapacá, from which a large production is expected, as it will work on a rich deposit.

Steps have been taken recently to renew operations on a large scale in Aguas Blancas, at the Penyon property, which has been the field of activity of a New York group.

The development of treatment methods continued during the year in various forms at several localities, but in most cases was confined to endeavors to improve the means of handling slime, or to undertake production of nitrate of potash from the mother liquors of the oficinas. At the Agua Santa property in Tarapacá, managed by J. T. Humberstone, the Butters filter which was installed in 1915 is still in operation, handling a slime pulp. W. R. Grace & Co., at the oficina Paposo, have put in a Burt filter, to handle a mixed pulp of coarser material than that usually recognized as a filter slime. Oficina Peregrina, in Toco, now has a Butters filter in operation, the construction of which was begun about two years ago.

The Cia. de Salitres de Antofagasta is now putting into service an Oliver filter to handle slime derived from the regular boiling treatment; and at oficina Celia, in Antofagasta, the Gibbs process plant has been at work since December, 1917, using weak solutions in a scheme of treatment which involves Dorr equipment and an Oliver filter. The pregnant solutions are afterward evaporated in an economical type of evaporator (triple effect), and brought up to crystallizing strength. The liquors are then precipitated by cooling.

It is of interest to note that observations made by the designers of the Gibbs plant while inspecting the mechanical features of the salt works of southern Michigan were of considerable help in the development of the final design of the evaporator they have adopted. After a year's work this plant has justified its design by an increased recovery of nitrate and a reduction in the consumption of fuel oil.

At oficina Cristina an interesting departure in caliche leaching is being adopted which can be summarized as follows: The contact of the dissolving solution with the lumps of caliche is carried on by means of a dripping and trickling action only. The level of the liquid in the dissolving vessel never rises high enough to come in contact

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with or submerge any part of the caliche being treated. This is done so as to avoid the formation of slimes, which vigorous boiling, in the ordinary treatment, is bound to produce. The liquor which accumulates in the bottom of the dissolving vessel is afterward cooled, and the fine crystals of precipitated nitrate are dried and washed on an Oliver sand filter.

Oficina Delaware continues its work, employing similar equipment to that used in oficina Celia, mentioned above, and has found it profitable to make nitrate of potash, using a recuperative refrigerating process on the mother liquor from the daily treatment.

At various oficinas several other methods of treatment are being tested, or apparatus is actually erected, or idle, which varies from the not unreasonable to the ridiculous.

Mining methods have not changed much, though oficina Delaware has made a beginning by the use of a mechanical excavator (drag bucket) to remove loose overburden.

Bank-blasting, by means of the familiar electric blasting circuit and a grouped series of drill holes, has been successful at oficina Aurelia, as an innovation in caliche mining, which resulted in a decided reduction in cost of powder and also in labor. This method is naturally best adapted where the occurrence of the caliche permits the working of a long "face."

The drilling of the holes in some oficinas has been done by Jackhamers, driven by a portable compressor, in combination with a gasoline engine, mounted on a narrow-gage railway truck.

As a whole, prevailing treatment methods demand too close a sorting of the raw caliche to permit any form of mining which involves the breaking down and extracting of the material in mass, without regard to local variations of the caliche in tenor or physical character. Therefore economy may perhaps best be sought in modifying and cheapening the present methods of loading and haulage from the caliche beds to those oficinas that still use the older methods. The adoption of rational improvements in treatment is bound to permit a parallel advance in mining methods as well.

NITRATE OF SODA STATISTICS (*a*)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at Close of Year. (*d*)
1905	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906	1,700,000	1,243,000	355,000	1,636,000	190.000	733,000
1907	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909	2,100,000	1,465,000	407,000	1,938,000	337,000	999,000
1910	2,300,000	1,651,000	501.000	2,241,000	310,000	969,000
1911	2,412,000	1,696,000	550,000	2,355,000	479,000	1,058,000
1912	2,478,000	1,908,000	481,000	2,508,000	310,000	1,004,000
1913(*b*)	2,739,530	(*c*)2,008,010	(*c*) 630,698	(*c*)2,739,530	380,419	472,543
1914(*b*)	1,847,586	(*c*)1,198,367	(*c*) 540,143	(*c*)1,847,586	.....	1,070,721
1915(*b*)	2,031,014	(*c*) 999,739	(*c*) 850,978	(*c*)2,030,964	.....	777,223
1916(*b*)	2,991,786	(*c*)1,609,381	(*c*)1,226,816	(*c*)2,985,300	.....	694,968
1917(*b*)	2,787,322	(*c*)1,053,786	(*c*)1,512,577	(*c*)2,769,062	.....	882,556
1918(*b*)	2,930,664	(*c*) 857,590	(*c*)1,919,762	(*c*)2,919,030	.....	811,922

(*a*) Statistics of W. Montgomery & Co., London. (*b*) Metric tons. Statistics of the International Institute of Agriculture, Rome. (*c*) Consignments from Chile. (*d*) On Chilean coast.

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MONTHLY PRODUCTION OF NITRATE ON THE WEST COAST (a)
(In tons of 2240 lb.)

	1915.	1916.	1917.	1918.
January	96,480	256,440	244,773	259,545
February	79,700	240,580	223,000	225,000
March	86,220	248,060	249,989	240,227
April	90,370	242,620	246,412	234,945
May	107,000	243,360	252,000	240,510
June	118,000	233,000	243,252	238,636
July	132,800	241,490	248,024	230,910
August	156,520	245,320	251,008	219,627
September	158,740	214,740	229,520	209,657
October	221,490	238,280	255,968	242,045
November	236,420	228,727	255,280	236,944
December	251,200	242,000	264,208	245,454
	1,734,960	2,874,617	2,963,434	2,823,500

(a) Data furnished by Parsons and Petit, New York.

United States.[1]—Discovery of large deposits of nitrate of soda in Amargosa Valley, Inyo County, Calif., was reported to the Secretary of the Interior in December, 1917, and he at once called upon the Geological Survey to make an examination. The Survey had already been systematically exploring other well-known nitrate deposits along the Amargosa River above Death Valley, among them those called the Upper Canyon, Lower Canyon and Saratoga deposits. The examination of the new deposits lasted from Dec. 26, 1917, to Apr. 4, 1918.

The results of the work may be briefly summarized as follows: In all, 78 trenches were dug, which had a total length of 3700 ft. and an average depth of 2 ft. 11 in.; 959 pits were dug to an average depth of 1 ft. 7 in.; 1085 samples were taken, from which 930 analyses were made. In the so-called Upper Canyon field, at Acme Siding, 98 acres is estimated to contain 1480 short tons of sodium nitrate, but an overburden of about 100,000 tons would have to be removed in order to extract the "caliche" containing this nitrate. In the so-called Lower Canyon field, 70 acres is estimated to contain 510 tons of sodium nitrate, the recovery of which would involve the removal of an overburden of about 50,000 tons. These two tracts are the largest and best of the ground examined, and, taken together, include 168 acres, which, if workable, might yield 1980 short tons of sodium nitrate, the recovery of which would involve the removal of 150,000 tons of overburden. The results of examinations at other places do not justify estimates of tonnage of nitrate.

The Survey's explorations have led to the following conclusions: (1) The nitrate in the Amargosa district occurs in a blanket of so-called "caliche," about 5 in. in average thickness, which lies about 9 in. below thee surface of the ground. The nitrate is accompanied by other salts,

[1] U. S. Geol. Surv.

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chiefly sodium chloride. (2) The soil above and the bedrock below the deposits contain insignificant amounts of nitrate. (3) The high dip and the great thickness of the strata covered by the prospecting make it improbable that deeper beds of nitrate occur in this region. (4) The "caliche" in general contains an average of less than 2.5 per cent. of sodium nitrate, the areal distribution of which is uneven. (5) The Zabriskie field, in which the newly found deposit was reported to lie, contains no commercially valuable nitrate. (6) The Upper Canyon and Lower Canyon fields, the most promising in the Amargosa district, together contain, according to careful estimate, about 168 acres of niter-bearing deposits, which, if worked regardless of cost, might produce about 1980 short tons of refined nitrate. (7) The quantity of nitrate available in the Amargosa district is so small and the cost of production would be so great that the district as a whole cannot be regarded as a source of commercial nitrate. (8) No further work on the areas already examined is justified, except, perhaps, as purely scientific research. (9) The occurrence of "caliche" nitrate deposits in the Amargosa district, rather than the usual cave or disseminated deposits, makes it seem possible, though improbable, that really valuable deposits of nitrate may occur elsewhere in the same general region. (10) Prospecting should be continued until all similar deposits in other districts have been tested sufficiently to determine their value.

South Africa.—Nitrates are now being commercially produced from the potassium-nitrate deposits in the Asbestos Mountains of Cape Colony.

Nitrate Supplies in the United States

The imports of sodium nitrate into the United States for the past few years, are as follows:

	Long Tons.	Value.	Price per Ton.
1913	625,862	$21,630,811	$34.54
1914	541,715	15,228,671	28.22
1915	772,190	22,959,997	29.73
1916	1,218,423	38,131,962	31.30
1917	1,543,213	60,437,526	39.16
1918	1,845,192	90,379,285	49.00

Shipments from Chile to the United States were still on a considerable scale at the close of the year, according to the *Chemical Trade Journal and Chemical Engineer*. Although the monthly rates stipulated in the contract for 680,000 tons entered into between the nitrate of soda executive and the Chilean Government have not been adhered to, the whole quantity has now been delivered, and it will be interesting to see how much

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nitrate will be exported during the next few months. British firms are not yet allowed to make independent purchases on the West Coast, and the big German houses in Valparaiso formerly transacting the bulk of the business are on the "black list," and consequently not doing business. In the meantime, the Allied governments, acting through their purchasing agents—themselves nitrate producers and exporters—are re-selling in different quarters the large quantities no longer required for the manufacture of explosives. The legitimate trade is thus brought to a standstill until such liquidation is completed, and the nitrate producers who hold large unsold stocks are placed in an awkward position; it is the more tantalizing in that the depreciation of the Chilean currency has materially reduced the cost of production, as also the export duty equivalent, thus enabling the acceptance of lower prices if there were a free market.

As a result of the enormous purchases made in 1918, and left on hand by the signing of the armistice, the U. S. Government has a surplus of 226,000 tons of sodium nitrate in the United States and 120,000 tons in Chile. An arrangement has been perfected between the director of sales for the War Department and American importers whereby the latter agree to dispose of the surplus in this country, the Government undertaking to sell to foreign interests the stocks held in South America. The importers who will have the responsibility for the sale of the surplus are held out of the primary market for shipment to the United States pending the distribution and sale of this surplus, or until import restrictions are removed by the signing of peace. The decision in this connection was reached at a conference between the director of sales, the nitrate committee, and representatives of the War Trade and War Industries boards.[1]

The War Department has also met with considerable difficulty in obtaining storage for this surplus. The railroads are lending aid and have agreed to find storage for 153,619 tons at the following points: Galveston, 8500 tons; New Orleans, 5000 tons; Mobile, 21,645 tons; Pensacola, 10,560 tons; Tampa, 6500 tons; Jacksonville, 27,237 tons; Fernandina, 4000 tons; Brunswick, 15,744 tons; Savannah, 36,433 tons; and Wilmington, 18,000 tons. In addition, the War Department has had to contract for expensive space, and a large number of commercial dealers have accepted nitrates for storage.[2]

Fixation of Atmospheric Nitrogen

The effect of the fixation of atmospheric nitrogen on the nitrogen industry is given in the following tables:

According to estimates by W. S. Landis, in 1914, at the outbreak of

[1] *Eng. Min. Jour.*, Mar. 1, 1919.
[2] *Eng. Min. Jour.*, Jan. 25, 1919.

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the European War, the producing rate of the world in short tons of chemical nitrogen, according to the best available statistics was as follows:

Material.	Short Tons of Nitrogen.
Nitrate of soda	425,000
Sulphate of ammonia	285,000
Arc process products	11,000
Cyanamid products	31,000
Synthetic ammonia and miscellaneous	12,000
Total	764,000

A corresponding estimate for 1919 shows the producing capacity of the world, including the United States Government nitrate plants now under construction, to be as follows:

Material.	Short Tons of Nitrogen.
Nitrate of soda	520,000
Sulphate of ammonia	330,000
Arc process products	15,000
Cyanamid products	360,000
Synthetic ammonia and miscellaneous	116,000
Total	1,341,000

An analysis of the production statistics of the world for ten years prior to the outbreak of the war shows a very uniform rate of increase. The curve is almost exactly a straight line. If we carry this rate of increase forward into the future, it indicates a producing rate for 1919 of 1,330,000 short tons of nitrogen, or essentially the same as our figure given above for actual production, 1,341,000 tons. Such a system of analysis, it seems, is justified, in view of the very uniform rate of increase noted for years prior to the war, and we are forced to the single conclusion that as relates to the world as a whole, there has not been the great over-expansion of producing capacity most of us have believed. The available nitrogen supply has then expanded under the influence of the war only to the point anyone would have predicted in the spring of 1914 from a study of its past statistics.

Soda Ash

United States.—Sodium carbonate in the form of soda ash is the foundation of the alkali industry, for it is used in the manufacture of glass, soap, and dyes, as well as caustic soda and most other sodium compounds. It is significant that the production of soda ash was well maintained in 1918 in spite of various difficulties incident to the war and of prices that were lower than those of 1917.

The sales in 1917 were 1,390,625 short tons, valued at $35,635,520, as compared with almost exactly the same quantity in 1918, valued at

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$38,028,000, according to the United States Geological Survey. The sales in 1916 were about 1,200,000 tons, valued at $18,000,000. These figures do not include sodium carbonate reported in the form of monohydrate and sesquicarbonate, for the production of which exact figures are not available, nor the soda ash consumed by the manufacturers in their own plants in making caustic soda and other sodium compounds. The quantity of soda ash used for the latter purpose in 1918 is estimated at 664,000 short tons, against 482,000 short tons in 1917.

Most of our soda ash is made from salt and limestone, but a small quantity is made in the West from natural sodium carbonate, chiefly that obtained from the water of Owens Lake, in southeastern California. The quantity made from this source in 1918 was 19,100 short tons, valued at $971,000, against 18,800 short tons, valued at $858,000, in 1917.

At some pulp and paper mills spent liquors from the digestors are evaporated and the residues incinerated to form impure soda ash, the use of which saves from 80 to 92 per cent. of the soda ash that would otherwise be required. A few mills make sodium carbonate by an electrolytic process, employing carbon dioxide generated in their lime kilns.

The exports of soda ash in 1918 were 119,218 short tons, valued at $7,805,550. This material went principally to Japan, Canada, Brazil, Australia, and Cuba, named in decreasing order of quantity exported. The need of soda ash in other countries has led to projects to build soda-ash plants in Canada and in Australia. The Canadian plant is to be built at Amherstburg, near Windsor, Ontario, where limestone and salt are found close together. A very large deposit of natural soda in British East Africa is now being exploited, and when this soda is shipped some of it may reach markets to which we have exported, but it is not likely to reach American markets. Although plants for making caustic soda by electrolysis are being erected in several countries that formerly made it from soda ash exported from the United States, other foreign plants that will use soda ash are under way that will probably maintain if not increase our exports.

Canada.[1]—The estimated consumption of soda ash in Canada is now 50,000 tons. During the past 4 years the lack of soda ash has been felt by a great many industries. Most of the soda ash used came from England, and, with the war, Canada was practically shut off from supplies. Now, however, the Brunner, Mond, Canada, Ltd., company has its new plant at Amherstburg, Ont., practically completed, and is in a position to supply Canadian requirements. They are using the "Solvay Process," by which practically all the soda ash now produced is made. The town

[1] *Can. Chem. Jour.*, Mar., 1919.

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of Amherstburg is well situated, and the raw products, salt, limestone, and ammonia, are easily available.

The produced soda ash is of general use in the manufacture of glass, soap, paper, wood-pulp, paints, leather, enameled ware, cleansers, textiles, oil refining, metal working, and metallurgical operations, washing powders, chemicals and drugs.

China.—It is reported that leading Chinese merchants in Tientsin are forming a company for the manufacture of soda, the natural salts of which are very abundant in the Province (Chihli).[1]

South Africa.—There is only one notable occurrence of soda in the Union, that at the Pretoria salt pan. This pan is a crater-like depression some 200 ft. below the surrounding country, and about 28 acres in extent. The bed of the pan, from which in the dry season all the liquid evaporates, consists of a black mud containing masses of trona, or solid crude carbonate of soda. The mud, which has been proved by boreholes to be at least 200 ft. deep, has the following analysis: Moisture at 120° C., 50.04 per cent.; Na_2CO_3, 16.00; NaCl, 14.65; $CaCO_3$, 3.01; insoluble, 12.03; organic matter, 3.55; total, 100.00 per cent. For the past six years the pan has been worked for the trona only, and 15,242 tons of the calcined product have been sold, chiefly for neutralizing the acid waters of the mines. At the present time much of this calcined trona is being exported to Japan. The South African Alkali, Ltd., which owns the lease of the pan, is now putting up a plant to treat the mud and prepare refined soda products. The production amounted in 1917 to 5675 tons, valued at £29,192.

SALT

United States.—The Delaware Indians made salt from brine springs in New York State and sold it to settlers as early as 1670, making probably the first commercial production of salt in this country. The manufacture of salt by white people in the United States was begun near Syracuse, N. Y., about 1788. Salt is the most commonly used mineral in the world, and no useful mineral except coal, perhaps, occurs in greater abundance or is more widely distributed in the United States.

Because of the universal use of salt in food and in food preservation and the lack of any substitute its output would be reduced only by most unusual conditions. There is always a general tendency toward an increase in production in the United States on account of the steady increase in population. The increasing use of salt by chemical and other industries helps to maintain a larger production from year to year. In view of the shortage of labor and other difficulties which hampered many

[1] *Comm. Rept.*, Sept. 11, 1918.

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industries during the war, a reduction in the output of salt might have been expected, but there was nevertheless a considerable increase. Figures compiled by the United States Geological Survey, from reports furnished by all producers of salt in the United States, show a total output of 7,238,744 short tons, an increase of 260,567 short tons, or 4 per cent., over the output in 1917. The total value was $26,940,361, an increase of 30 per cent. over the total value in 1917, which was $19,940,442.

The production of salt in 1918, by States, is shown in the following table:

	Short Tons.
California	204,957
Kansas	819,504
Michigan	2,403,125
New York	2,130,530
Nevada	970
Ohio	1,089,887
Texas	79,657
Utah	94,204
West Virginia	26,077
Hawaii, Idaho, Louisiana, New Mexico, Oklahoma, Porto Rico, and Virginia	389,833
	7,238,744

The production of rock salt amounted to 1,683,941 short tons, an increase of about 5 per cent., but the value was $5,684,661, an increase of 46 per cent. The output of evaporated salt amounted to 2,724,203 short tons, valued at $20,010,435, an increase of nearly 10 per cent. in quantity and 34 per cent. in value. The production of salt in brine was 2,830,600 short tons, valued at $1,245,265, a decrease of 2 per cent. in quantity, but an increase of 15 per cent. in value.

Michigan, New York, and Ohio continued to hold first, second, and third places respectively in quantity produced.[1]

PRODUCTION OF SALT IN THE UNITED STATES (a)
(In barrels of 280 lb.)

Year.	California.	Kansas.	Louisiana.	Michigan. (c)	Nevada.	New York. (c)	Ohio and W. Virginia. (b)	Texas.	Utah.	Other States.	Total, Barrels.
1908	899,028	2,588,814	947,129	10,194,279	9,714	9,005,311	3,572,635	(d)	242,678	1,291,042	28,750,630
1909	886,564	2,769,849	(d)	9,966,744	16,107	9,880,618	3,835,267	(d)	246,935	2,505,562	30,107,646
1910	937,514	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	382,164	249,850	983,128	30,305,656
1911	1,086,163	2,159,859	(d)	10,320,074	12,856	10,082,656	4,485,886	385,200	272,420	2,391,710	31,196,824
1912	1,090,000	2,573,626	(d)	10,946,739	12,536	10,502,214	5,408,300	373,064	283,293	2,135,036	33,324,808
1913	1,082,993	2,698,079	(d)	11,528,800	8,971	10,819,521	5,424,056	355,529	330,443	2,189,913	34,438,305
1914	(d)	2,967,864	(d)	11,670,976	4,436	10,389,314	5,628,265	433,979	375,457	2,332,649	34,804,683
1915	1,048,457	3,765,164	(d)	12,588,788	6,929	11,217,471	6,112,482	444,978	394,850	2,652,377	38,231,496
1916	1,124,236	4,564,793	(d)	14,918,278	(d)	14,087,750	6,706,193	541,157	433,236	2,834,880	45,449,329
1917	1,536,814	5,335,543	(d)	16,078,136	(d)	15,457,636	7,511,764	608,436	565,679	2,750,114	49,844,121
1918	1,463,979	5,853,600	(d)	17,165,179	(d)	15,218,071	7,971,172	568,978	672,886	2,427,378	51,341,243

(a) Statistics of the U. S. Geological Survey except for New York since 1908, which are from report of the State Geologist. (b) The production of Pennsylvania since 1908 is included in "Other States." (c) Includes brine used in manufacture of alkali. (d) Included in "Other States."

[1] U. S. Geol. Surv.

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CONSUMPTION OF SALT IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1904.....	3,084,200	$6,021,222	166,140	$467,754	13,964	$113,625	3,236,376	$6,375,351
1905.....	3,635,257	6,095,922	161,159	492,189	34,238	239,223	3,762,178	6,348,888
1906.....	3,944,133	6,658,350	170,505	502,583	33,988	274,627	4,080,650	6,886,306
1907.....	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908.....	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909.....	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8,522,541
1910.....	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911.....	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912.....	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913.....	4,821,368	10,123,129	150,601	416,375	70,289	515,194	4,901,680	10,024,310
1914.....	4,872,656	10,271,358	130,752	385,752	82,295	586,055	4,921,113	10,071,055
1915.....	5,352,409	11,747,686	123,576	366,475	80,474	613,850	5,395,511	11,500,311
1916.....	6,632,906	13,645,947	121,967	342,588	84,065	567,411	6,670,808	13,998,535
1917.....	6,978,177	19,940,442	65,840	280,135	113,993	1,000,773	6,930,024	19,219,804
1918.....	7,238,744	26,940,361	40,316	284,032	136,783	1,677,577	7,142,277	25,546,816

Australia.—It is proposed to develop the salt deposits on Casuarina island at the mouth of the Fitzroy river, not far from Mount Morgan. Bores on the island show the presence of two beds of gravel and sand containing brine, which rises in the bores to within 20 ft. of the surface. Coal and limestone, the other two raw materials required in the ammonia-soda process, are plentiful locally.[1]

The "Queensland Mineral Index" records a number of localities in this State where salt lakes occur, as well as a number of localities where the preparation of salt from sea water or from crude salt deposits has been attempted.

The principal salt lakes of Queensland are located as follows:

Galilee, 50 miles N.E. of Aramac.
Buchanan, 100 miles N.N.E. of Aramac.
Lake, W. of Lake Philippi, near western border. Lat., 24° 15′.
Lake, near Lake Muncoonie, near western border. Lat., 25° 10′.
Müeller (soda), 16 miles N.E. of Aramac.

As places offering facilities for salt manufacture, the salt pans near Port Alma and the mouth of the Fitzroy River are exceptionally favorable. Other suitable localities occur near Brisbane, Gladstone, Broadsound, Mackay, etc., near the coast. Casuarina Island, near Rockhampton, is also mentioned. The works here were erected to treat the brine from a local well.

In addition to the foregoing, one should mention the strip of country along the Gulf of Carpentaria from Burketown to the McArthur River. Here salt pans occur in a large number of places, the best of which are at the mouth of the Weare River in the Northern Territory. The salt pans

[1] *Min. Mag.*, Feb., 1919.

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here are flooded with water from the Gulf at the February-March king tides. The waters remain in the pans and evaporate during the long dry season (March to October). For many years the stations on the Barkly Tablelands have annually sent luggers from Borroloola to the Weare to collect salt, which forms a crust many inches thick over these pans, and can easily be shoveled up and bagged. The present high price of salt and soda compounds gives some importance to this salt occurrence, for here the salt is formed naturally without the construction of any artificial evaporating pans.[1]

Canada.[2]—In 1918 for the first time since 1907 the quantity of salt sold from Canadian salt wells shows a falling off as compared with the previous year. The total sales in 1918 including the salt equivalent of brine used for chemical manufacturing were 131,727 tons valued at $1,285,039, as against sales in 1917 of 138,909 tons valued at $1,047,792. Notwithstanding the decrease of 7182 tons, or 5 per cent. in quantity, the total value of the sales, it will be noted, shows an increase of $237,247, or 22.6 per cent. These values as far as possible exclude the value of packages. The value of packages used in 1918 was $574,033 and in 1917 $403,879. By grades the production in 1918 included: table and dairy, 34,324 tons; common fine, 53,908 tons; common coarse, 41,454 tons; and land salt, 2041 tons. The production by grades in 1917 was: table and dairy, 34,252 tons; common fine, 65,117 tons; common coarse, 37,398 tons; and land salt, 2142.

The number of men employed in 1918 was 302; wages paid, $286,781, while in 1917 the number of men employed was 309 and wages paid $249,073.

The Canadian production was obtained as usual entirely from the salt field in southern Ontario. Some years ago there was a small production from brines near Sussex, New Brunswick and at lake Winnipegosis in Manitoba. A deposit of rock salt of considerable thickness is being opened up in the neighborhood of Malagash, Cumberland County, Nova Scotia. This is the first known discovery of rock salt in the Maritime Provinces and the first in Canada to be discovered at a depth sufficiently shallow to enable it to be won economically by actual mining.[3]

The exports of salt in 1918 were 893 tons valued at $16,743. The imports of salt were 165,494 tons valued at $1,267,169, and included: 51,450 tons of fine salt in bulk, valued at $294,676; 13,941 tons of salt in packages, valued at $156,736; and 100,103 tons of salt imported from Great Britain for the use of fisheries, valued at $815,757.

[1] *Queens. Govt. Min. Jour.*, Apr. 15, 1918.
[2] Prelim. Rept. Min. Prod. of Canada, Can. Dept. of Mines.
[3] "Notes on a Discovery of Rock Salt in Nova Scotia." L. H. Cole, Mines Branch, Ottawa. *Can. Min. Jour.*, Jan. 8, 1919.

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The exports of salt in 1917 were 8643 tons valued at $94,364, and the total imports 170,810 tons valued at $1,088,205.

The calculated consumption of salt in 1918 was 296,328 tons valued at $2,535,465, as compared with a consumption in 1917 of 301,076 tons valued at $2,041,633 (the value of the imported salt being that at point of origin).

Iceland.—Plans are being discussed for building a salt industry in Iceland. In 1914 a 30-year concession was granted for salt production, but small progress has been made. It is now the plan to combine the salt production with the contemplated electric-power stations in Iceland, and with the mining and smelting of iron. In this way it is claimed that there is a possibility of covering not only Iceland's own salt consumption of about 100,000 tons, but also of exporting salt to Denmark.[1]

India.—As a result of the recent shortage of a salt and the consequent high prices that have prevailed, various questions concerning this industry have been brought more prominently before the public than usual. Nevertheless, it is surprising how very little is known, even among those who are actively engaged in the production of salt, of the possibilities this industry offers for the profitable investment of capital, if it is developed on modern scientific lines. Without attempting to trace the history of the industry, which by the way, is a very ancient one, it will be sufficient to outline briefly here the condition of the industry as it is at present, and then to indicate some of the developments which might be attempted if the necessary capital and technical knowledge is brought to bear on the subject.

The manufacture of salt is carried on at some fifty different points, dotted at short intervals along the whole of the east coast of the Madras Presidency. With one or two exceptions, the methods of manufacture in use are traditional and are handed down unchanged from generation to generation, so that it is not surprising to find that they are the most primitive imaginable and have remained wholly uninfluenced by the vast developments of modern science, nor that the salt produced is so heavily contaminated with dirt that it is always of some shade of brown or gray in color and never white, as it should be. Further, it is always moist and sticky, a defect which arises from the presence of magnesium chloride, one of the constituents of sea water.

It is in the development of the by-products of the industry that the most promising field for enterprise lies; they are very numerous and include salts of magnesium and potassium and also chlorine and bromine, which are not only exceedingly important for industrial and agricultural purposes, but have hitherto been obtained almost exclusively from Germany, where they are found in great abundance in the salt mines at

[1] *Comm. Rept.*, Oct. 22, 1918.

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Stassfurt. These substances are all to be found in the bitterns, or mother liquor, remaining after the removal of the common salt, and the quantity of bitterns that is annually run to waste in this Presidency amounts to more than a quarter of a million tons.[1]

Japan.—The Salt Monopoly Administration has so far proved a failure, states the *Japan Gazette*. Since last summer complaints have been heard in all quarters as to a shortage in the supply of salt. The manufacture of salt by the monopoly authorities last year was reduced from 1,020,000,000 to 800,000,000 kin (about 1,360,000,000 to 1,066,660,000 lb.). The consumption of salt in Japan in recent years amounted to 1,470,000,000 kin (about 1,960,000,000 lb.) annually. There will therefore be a deficit of some 670,000,000 kin (about 993,330,000 lb.) this year. Naturally the price is ruling high. The monopoly is said to have suffered a loss of over 400,000 yen ($199,400) last year. The authorities are now trying to import salt from Tsingtau and China to make up the deficit.[2]

Korea.—The output of salt at the Government salt pans at Kwangyang, near Chinnampo, Korea, for 1918 is expected to exceed 80,000,000 kin (1 kin = 1.32 lb.) according to an issue of the *Seoul Press*. The extension of the salt pans as approved by the Diet will be started the beginning of August. The estimate for the work is 300,000 yen ($150,000), and is expected to be completed in 8 months.[3]

Netherlands.—In 1903 an official Government report noted the presence of salt in Gelderland and Overyssel provinces, on the German frontier. In 1911 salt was found by boring in several localities to a depth of several hundred feet. The Government approved a proposition to develop the salt beds, but the matter was not pressing and nothing definite was done till the difficulty of importing salt caused by the war forced an interested consideration of the subject, which has resulted in the formation of a stock company, with Government approval and patronage.

The thickness of the principal salt bed is estimated at about 19 meters (62 ft.), and it is calculated that a surface of 100 hectares (247 acres) would contain 38,000,000 tons of salt. However, the concession includes a surface of 3000 hectares (7413 acres), under which, according to the calculation, there might be 1,140,000,000 tons of salt. Work started in the summer of 1918. After the erection of the necessary boring towers, engine rooms, dwellings and other essential buildings, boring began, and it has already reached a depth of 43½ meters. The boring of the first 7 meters offered no difficulties; from 7 to 80 meters clay strata are

[1] *Comm. Rept.*, Mar. 6, 1919.
[2] *Comm. Rept.*, Apr. 16, 1919.
[3] *Comm. Rept.*, Aug. 22, 1918.

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looked for, and from 80 to 320 meters it is expected that rock will be encountered. It is thought that rock salt will be found at 320 meters. A deep-well pump will be inserted in the boring, by means of which it is hoped to lift 7 cubic meters (1850 gal.) of brine per hour.

The total annual consumption of salt in Holland is about 170,000 tons.

New Zealand.—There is a marked shortage of salt for all purposes in New Zealand, especially table and common salt. The price has increased considerably during the last year, and the outlook does not seem bright for a sufficient supply in the near future.

In July, 1917, fine salt was selling locally for $31.63 per ton, and by October the price had increased to $65.69 per ton and at the end of the year $80.29 a ton.

The imports for the 5 years from 1911 to 1915 ranged from 20,250 to 25,275 tons, averaging about 22,162 tons per annum, and for 1916 the figures jumped to 32,298 tons, but dropped to 16,101 tons for 1917. Of the imports during 1917, the United Kingdom supplied 8928 tons; Australia, 5577 tons; and the United States, 574 tons.

It would seem that there is an opening for additional salt from the United States at this time, providing shipping space can be procured and prices met.[1]

Siberia.[2]—Salt is found in Siberia in saline lakes and salt springs and in the form of rock salt. In the Tobolsk Government there are 74 lakes, the majority of which are found in Baraba, especially in the Tyukalinsk Uyezd. The steppe territories are rich in salt lakes, of which there are 52, not more than 15 being worked, such as the Koryakovsk, the Karasuksk, the Karabash, and others. Excluding three lakes that are leased by the Treasury, all the others are worked, without any control whatever, by the local Kirghiz and Cossacks. The saline lakes of the Semipalatinsk Province are distributed on both sides of the River Irtysh, which makes them very convenient as regards placing their product on the market. Especially rich in saline lakes is the Pavlodar Uyezd, and the salt from this place goes to the Tobolsk and Tomsk Governments. Lake Karabash, which is very rich in salt, is situated at a distance of 8 versts to the southwest of Semipalatinsk. The saline lakes of the Akmolinsk Province are found in steppe localities and not far from settlements. The best salt is that of the Koryakovsk Lake, near Pavlodar, but even its quality is not very good. The quantity of salt in this lake is about 2,500,000 poods (45,000 short tons).

In the Tomsk Government also there are many salt lakes, especially in the Barnaul Uyezd; but there are being worked only the Borovy

[1] *Comm. Rept.*, May 11, 1918.
[2] *Comm. Rept.*, May 9, 1919.

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Lakes, in the southwest, and the Burlinsk Lake, near the boundary of the Uyezd, which is 30 versts (20 miles) in circumference and contains several million poods of salt. In 1911 the Burlinsk Lake yielded 988,000 poods (18,000 tons) of salt. From the Borovy Lakes the salt goes to Barnaul, from there to Tomsk, and so on farther. More important for the export of salt is the Burlinsk Lake, which is near the overland trading highway of the steppes. In 1911 the lakes of western Siberia and the Yenisei Government yielded 6,182,000 poods (111,600 tons) of salt.

In the Yenisei Government salt is found at the mouth of the Anabara, in the Turukhansk region (Trinity Springs), and in the Minusinsk Uyezd, where the Tagarsk, the Beisk, the Shunet, and other sources are known. The large-scale production of salt for a wide market exists only in the Semipalatinsk Province and in the Minusinsk Uyezd, but there is a large production for the local market in the Altai region. In Siberia the lake salt is transported chiefly on the rivers. The amount of salt brought in from European Russia by rail constantly increases.

In the Irkutsk Government the chief center of salt production is the works at Usolie, northeast of Irkutsk, where the salt is obtained from a brine, the density of which is 6½ to 7½° Baumé. In Usolie about 400,000 poods (7200 tons) of salt annually are obtained. Furthermore, in the Kirensk Uyezd, where the Ust-Kuta falls into the Lena, there is the Ust-Kuta salt refinery, which produces about 75,000 poods (1350 tons) of salt per year. The impossibility of shipping the salt to the Transbaikal and on to the Amur hinders the development of salt production at this point. The Usolie and the Ust-Kuta works belong to the Government. On the River Ilim there is a private refinery producing 25,000 poods (450 tons) per year. The total production of the Irkutsk Government is not more than 600,000 poods (10,800 tons) of salt annually.

The Transbaikal is not rich in good salt. The Kiransk deposits are well known, near the Mongolian border in the Troitskosavsk Uyezd, where brines are evaporated from spring water; on the other hand, the evaporation of salt at the lakes of the Selenginsk Uyezd is very costly because of the lack of cheap fuel. For this reason only about 30,000 poods (540 tons) a year is produced in this locality.

In the Yakutsk Province also there are found saline springs, as well as deposits of rock salt. The banks of the Lena River are rich in saline springs. The most northerly spring is found on the right bank of the Lena, 180 versts (120 miles) below Stolby. The little River Solyanka ("Salt Creek"), 25 versts (17 miles) below Olekminsk, highly justifies its name; the great number of springs originating in the gypsum strata and falling into this river makes its water so salty that it was formerly used by the inhabitants of the village situated at the mouth of the river

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as long as the price on Vilyui salt remained high. Saline springs have been discovered along the River Namana and its affluent, the Bungunni, and there is a saline lake near the River Tongo, a right affluent of the Vilyui. Not far from there, on the natural boundary of the Kysyl-Tus, cropping out from the red marl clays of the high right bank, are tremendous white cliffs of rock salt. This deposit, known to the Russians from the middle of the eighteenth century, has not been exploited up to the present time, although the quality of the salt is not surpassed by that of the Iletska. Thirty versts (20 miles) from this point, also on the right bank of the Vilyui, is the well-known Kempendyaisk saline spring. In the summer time this is merely a small river flowing out of a crater-like depression; when winter comes with its sharp frosts and the upper layers of the soil, which had thawed during the summer, freeze again, the spring begins to shoot upward periodically in the form of a fountain to a height of about 1½ sazhens (10½ ft.), ejecting an almost saturated (*i.e.*, 25 per cent.) saline solution. The latter, collecting in a large natural reservoir, under the influence of the low temperature and the evaporation, gives rise to the formation of an original mineral called "kriogalit," a hydrate of sodium chloride. This occurs in accurately formed transparent crystals, great masses of which, disintegrated by the spring warmth, are converted into heaps of ordinary evaporated salt. During the summer it dries out and in the winter, when the sledding routes have been opened, several thousand poods of it are sent to salt stores in various points of the territory.

The Kempendyaisk spring is capable of yielding up to 100,000 poods (1800 tons) of salt annually. This spring is threatened by the danger of inundation from the River Kempendyai, since the discharging orifice of the spring lies only 1 sazhen (7 ft.) above the level of the water in the river, and the latter at the time of the spring flood tears up its banks and changes its course. Owing to the sparsity of the population in the territory and the poor means of communication, very little salt is produced—just enough to satisfy the local demands.

In the Amur and Maritime Provinces and in Kamtchatka salt deposits are not found.

In general, the salt question is a very good illustration of the technical backwardness of Siberia and of its lack of money, for, notwithstanding the urgent need of good salt for salting fish at the fisheries and for meat in the cattle-raising regions, the Altai and Kirghiz salt is worked only in the crudest manner and is not cleaned as it should be. The same may be said of the Minusinsk salt.

In the Irkutsk Government and in the Yakutsk Province the production of salt is extremely limited, owing to the lack of cheap ways of transport

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to the consuming markets. In the Irkutsk Government, the Transbaikal and the Priamur salt is very expensive. At present salt is brought into western Siberia at the rate of 500,000 poods (9000 tons) annually from European Russia and even from Germany. However, there is no doubt that the salt industry will develop rapidly in Siberia as a result of the abundance of natural deposits and the ever-growing demand for its use in the canning of fish and meat products.

South Africa.—No deposits of rock salt are known in the Union, but in the Cape, the Orange Free State and the Transvaal Provinces a very large quantity of rough salt is made from the liquor of salt pans. These pans are shallow depressions, often of several square miles in extent, in the surface of the more arid districts. They are without outlet, and in the rainy season collect a foot or two of water in their beds. In the dry season this evaporates, leaving a skin of impure salt on the surface, and a strong solution of brine in the sub-surface mud. This brine is pumped or bailed out; formerly it was evaporated by solar heat in shallow dams or in canvas sails. At the present time it is mostly concentrated by solar evaporation, and finally precipitated by artificial heat. The total production in the Union in 1916 was as follows:

	Long Tons.	Value.
Cape of Good Hope	25,505	£54,528
Transvaal	6,592	10,763
Orange Free State	24,170	41,012
Total for Union	56,267	106,303

Sodium Sulphate

While large quantities of sodium sulphate, or Glauber's salt, are produced as by-products in the manufacture of hydrochloric and nitric acids, considerable quantities are also available as natural salts in the desert regions of the western United States, and other countries.

Important deposits of this salt with quality and quantity reasonably assured have been located in southwestern Saskatchewan, Canada. There is a demand for this product in the pulpwood and glass industries. The former industry has been well established in central and western Canada and the latter may yet be an established industry in Manitoba, since there are large deposits of glass sand available in the vicinity of Lake Winnipeg.

Glauber's salt is obtained from the lakes of the Koktchetavsk Uyezd of the Akmolinsk Province in Siberia (up to 10,000 poods, or 180 tons), in the Barnaul Uyezd (in the Great and Little Marmyshansk Lakes up to 350,000 poods, or 6300 tons), and in the Troitskosavsk Uyezd, from the Kiransk spring.

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SULPHUR, PYRITE AND SULPHURIC ACID

SULPHUR

The greater proportion of the sulphur produced in the United States comes from either the Union Sulphur Co., at Sulphur Mine, Calcasieu Parish, La., or the Freeport Sulphur Co., Freeport, Brazoria County, Texas, although production in small amounts is each year reported from a half dozen or more other companies. Due to the fact that practically the entire production comes from the two companies, exact production statistics have been withheld for several years, but are now made public.

SULPHUR PRODUCED AND SHIPPED IN THE UNITED STATES, 1909–1918.
(U. S. Geol. Survey)

Year.	Mined.	Shipped.		Year.	Mined.	Shipped.	
	Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.		Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.
1909.....	273,983	258,283	$4,783,000	1914.....	417,690	341,985	$6,214,000
1910.....	247,060	250,919	4,522,000	1915.....	520,582	293,803	3,955,000
1911.....	205,066	253,795	4,573,000	1916.....	649,683	766,835	12,247,000
1912.....	787,735	305,390	5,289,000	1917.....	1,134,412	1,120,378	23,987,000
1913.....	491,080	319,333	5,614,000	1918.....	1,353,525	1,266,709	27,868,000

At the same time, imports have dropped to less than 100 tons, so that the United States is now entirely dependent on herself for sulphur supplies. Exports have increased to about double what they were before the war, and would doubtless have increased much more but for the shortage of shipping facilities.

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES
(In tons of 2240 lb.)

Kind.	1913.		1914.		1915.		1916.		1917.		1918.	
	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.
Imports:												
Crude.....	14,636	$278,056	22,810	$409,537	24,647	$405,990	21,510	$364,787	973	$20,176	55	$1,692
Flowers....	5,899	115,574	621	17,214	647	23,146	425	18,408	.....	.....	.....	.....
Refined....	1,234	29,091	1,800	47,568	988	30,335	455	15,020	.....	.....	.....	.....
Precipitated	350	17,690	105	14,161	85	12,987	66	12,940	37	9,164	27	7,850
Total imports..	22,119	$440,411	25,336	$488,490	26,367	$472,458	22,456	$404,784	1,010	$29,340	82	$9,542
Exports....	89,221	1,559,761	96,163	1,807,334	37,271	724,679	128,755	2,505,857	152,736	3,500,819	131,092	3,626,638

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In the suit of the Union Sulphur Co. vs. the Freeport Sulphur Co., the U. S. Circuit Court has held that the Frasch patent lacked inventive substance.

As this process covers the method by which practically all of the sulphur is produced in this country, this leaves the field open to the several new companies that are preparing to enter the field, unless the present decision should be reversed in the Supreme Court, to which the case will doubtless be taken, in view of the vast commercial importance of the decision.

Alaska.—The known sulphur deposits of Alaska are of volcanic origin and lie in the belt of active volcanoes that extends through the Aleutian Islands and Alaska Peninsula. The deposits on Unalaska and Akun islands and near Stepovak Bay, on Alaska Peninsula, were examined in the summer of 1917 by the United States Geological Survey. The examinations showed that though there is some sulphur at each place examined there is little hope that any of it can be profitably mined at present or in the near future, for the deposits are of small areal extent and are probably shallow, supplies and labor are not at hand, the open season is short, the difficulties of transporting the material from the mines to ships would be great, and the haul to the larger markets would be long.[1]

Louisiana.—The mines of the Union Sulphur Co. still continued to be the chief producer. Under stress of war demands this company has increased its pre-war production about 300 per cent.

On Aug. 6 a cyclone caused considerable damage in the vicinity. The producing wells were interfered with temporarily, owing to the derricks being thrown down; roofs were blown off of the boiler houses, and smoke stacks blown down. The damage, however, was not serious, and was soon repaired, shipments in the meantime being made from the reserve stock, which at all times amounts to several hundred thousand tons.

New Mexico.—Small deposits of sulphur have for some time been locally known in Jemez Canyon, Sandoval County, New Mexico. The deposits occur in two places, one in the Canyon de San Diego Grant, about five miles above Jemez Springs, nearly three-fourths of a mile below the forks of the creek, and the other at Sulphur Springs, in the Baca location, about 14 miles above Jemez Springs. The nearest railroad points are Bernalillo and Albuquerque, on the Atchison, Topeka & Santa Fe R.R., about 45 and 60 miles, respectively, south of Jemez Springs by the wagon road.

The sulphur ore at the deposit first named, which may be called the

[1] U. S. Geol. Surv.

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San Diego deposit, consists of residual material from carboniferous limestone leached by acidulated waters and permeated by sulphurous vapors, which have deposited free sulphur in the crevices and pores of the upper few feet of rock. The deposit at Sulphur Springs is similar except that it occurs in rhyolite. About two miles above Sulphur Springs, and at several places in Jemez Canyon between Sulphur Springs and the lower deposit, hot springs or leached rocks indicate similarly active waters and vapors on a smaller scale. Hot sulphuretted water also occurs at Jemez Springs. These phenomena occur in a zone more than 15 miles in length along the general line of Jemez Canyon and suggest the occurrence of a deep fracture or group of fractures in the earth's crust along which acidulated waters and sulphurous vapors have risen and deposited sulphur.

Examination led to the conclusion that the quantity of available sulphur in the Jemez Canyon deposits is too small to be of commercial importance, especially in view of their inaccessibility.[1]

Texas.—The sulphur deposits of Texas are of two distinct types, in widely separated localities. Along the Gulf coast, associated with the oil domes, are deepseated deposits which are worked by the Frasch process. In the western part of the State, in Culberson and Reeves counties, in the region just south of the New Mexico boundary and west of the Pecos River, are numerous surface deposits which are mined and the ore subjected to liquation. The chief operator in this district is the West Texas Sulphur Co. A more detailed description of these deposits was given in the preceding volume of MINERAL INDUSTRY.

Near Freeport, in Brazoria County, the Freeport Sulphur company has been extracting sulphur by means of the Frasch process for several years, and, in size of production stands second to the Union Sulphur Co. of Louisiana.

During 1918 the Texas Gulf Sulphur Company[2] continued its campaign of development of the sulphur deposit near Matagorda, Texas. The company owns or controls some 1100 acres covering practically the entire Matagorda "Big Hill." Sulphur was discovered in a saline dome under the "Big Hill" during the early days of exploration for oil in Texas, but it was not until 1917 that a systematic campaign of development was begun. It has been reliably announced that on the eastern side of the Matagorda dome a remarkably rich and thick body of sulphur has been proven by careful and methodical drilling, and that the extent of the deposit is very large. A definitely developed tonnage of sulphur running well into eight figures has been reported.

[1] P. S. Smith, *Eng. Min. Jour.*, Sept. 7, 1918.
[2] Data supplied by Spencer C. Browne, Consulting Engineer for the Texas Gulf Sulphur Co.

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The property is on the Matagorda branch of the Santa Fe railroad system, and is but 6 miles from the shore of the Gulf of Mexico.

The sulphur occurs in a saline dome shaped somewhat like an open umbrella, and lying under approximately 1000 ft. of mud and clay. The sulphur is intimately associated with crystalline calcite in a porous, fissured mass, containing salty sulphurous water and some gas. Immediately above the sulphur horizon is a capping of lime rock; below it are beds of gypsum and rock salt.

The construction of a steaming plant for mining the sulphur was begun by the Texas Gulf Sulphur Co. during 1918, and was completed early in 1919. Active production was started in March, 1919, averaging 1200 tons daily; the maximum daily production was over 2100 tons.

The mechanical equipment is as follows: fourteen 700-hp. Stirling water-tube boilers, designed for 200 lb. steam pressure; two 500-kw. General Electric steam turbo-generators; four Laidlaw steam-driven air compressors, each with displacement capacity of 475 cu. ft. per min., and delivery at 500 lb. operating pressure; three Webster feed-water heaters, each with capacity to heat 3350 gal. per min. from 90 to 160° F.; three Epping-Carpenter boiler feed pumps 16 by 9 by 18 in.; one 14-in. duplex Worthington steam service pump; three 6-in. Allis Chalmers centrifugal service pumps; eighteen 10 by 6 by 16 high-pressure and seventeen 12 by 7 by 16 low-pressure Epping-Carpenter mine-water pumps; eight mine-water heaters designed to use live steam for heating. A complete machine shop has also been erected and suitably equipped. All the above equipment is covered with fireproof steel housing. Oil fuel will be used, and is stored in two 55,000-bbl. tanks.

The normal operation of the water system will be as follows: The service pumps deliver to the feed-water heaters, thence to the feed pumps and low-pressure mine-water pumps, thence through the mine-water heaters to the high-pressure mine pumps, and thence to the sulphur wells. Water will be obtained from the Colorado River, and a reservoir of 240,000,000 gal. capacity has been constructed to hold a reserve in case of drought. A system of shallow wells has also been bored for an additional source, if needed.

The company has constructed for its employees modern cottages with complete domestic water service and a modern sewerage plant.

Utah.—In December the first unit of the plant of the Utah Sulphur Corporation went into commission. The corporation was organized for the purpose of taking over the sulphur deposits at Sulphurdale in Beaver County, and the Purgatory deposits just across the line in Millard County.

This remarkable deposit of sulphur was discovered by the pioneers

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early in the fifties and was operated in a desultory manner up to the eighties by sheepmen who used a sulphur solution for sheep-dipping. The sulphur was also used, locally, in the manufacture of matches and for bleaching purposes.

The deposit was located in 1887 and was worked under the name of the Cove sulphur mine by Dickert & Meyers for a number of years, the production being used in supplying local demands. In 1904 the property was purchased by the Mormon church, and was operated quite extensively up to 1911, the property being abundantly equipped and surface improvements made answering the requirements of the time. However, heavy competition and a disastrous fire and explosion put an end to the operations.

Prior to the taking over of the properties by the Utah Sulphur Corporation the mining practice consisted in the sinking of pits and openings in the sulphur field. These openings were gradually enlarged as work progressed and teams and scrapers were employed in the removal of the product. In no case, however, were the workings carried deeper than 15 to 20 ft., owing to the inflow of water caused by seepage. However, diamond-drill prospecting has shown that the deposits go down to a considerable depth, and that the grade of the material improves with increasing depth. The equipment installed under church management was successful in its operation, and although partially destroyed by fire and the explosion that followed, much of it was available for the reconstruction of the new plant. It has been estimated that all rock which yields 20 per cent. or better should pay for treatment.

WORLD'S PRODUCTION OF SULPHUR (*a*)
(In metric tons)

Year.	Austria. (*b*) (*e*)	Chile.	France. (*b*)	Germany.	Greece.	Italy. (*b*)	Japan.	Spain.	United States. (*g*)	Total.
1901.....	5,048	2,516	6,836	963	2,336	563,096	16,548	610	6,977	604,930
1902.....	3,826	2,636	8,021	487	1,391	510,333	18,287	450	7,565	552,996
1903.....	4,610	3,560	7,375	219	1,266	553,751	22,914	1,680	35,660	631,035
1904.....	6,431	3,594	5,447	209	1,225	527,563	25,587	605	196,583	767,249
1905.....	8,542	3,470	4,637	205	1,126	568,927	24,652	610	218,440	830,609
1906.....	15,258	4,598	2,713	178	(*d*)1,000	499,814	27,589	700	298,704	845,956
1907.....	24,199	2,905	2,000	176	(*d*)1,000	426,972	33,329	3,612	312,731	801,911
1908.....	17,429	2,705	2,189	811	(*d*)1,000	445,312	33,419	13,872	312,700	829,437
1909.....	12,856	4,508	2,900	1,185	(*d*)1,000	435,060	36,317	21,750	303,000	817,608
1910.....	15,976	3,823	2,641	1,272	.....	430,360	43,848	30,113	259,699	787,732
1911.....	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	776,629
1912.....	14,979	4,431	1,000	(*c*)	2,016	357,547	55,005	42,344	308,530	785,852
1913.....	10,561	6,647	659	.....	*Nil.*	386,310	59,481	62,653	316,783	806,386
1914.....	.....	10,008	.....	.....	*Nil.*	377,843	75,308	(*e*)	347,491	(*f*)877,000
1915.....	.....	(*c*)	.....	.....	*Nil.*	358,107	73,369	28,937	299,133	(*f*)860,000
1916.....	.....	.....	.....	.....	*Nil.*	269,374	108,100	46,923	779,181	1,203,578
1917.....	.....	.....	.....	.....	.....	211,847	117,990	84,979	1,138,416	1,553,232

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary. (*f*) Totals estimated by the International Institute of Agriculture, Rome. (*g*) Shipped from mines.

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The nature of these deposits suggests that mining operations can be carried on economically and successfully by steam shovels, and these will be installed, one at each plant. All machinery is to be motor-driven, power to be taken from the transmission line of the Beaver Valley Power Company.[1]

France.—Investigation into the local market discloses that there is at present no market for sulphur products, and, in fact, the same condition appears to hold for all of France in any large commercial way. This is due to the fact that the French Government controls the buying and distribution of these products. Sulphur will continue to be until July 31, 1919, under Government control. The purchase and distribution is done by L'Office Central des Produits Chimiques Agricoles.

Lump sulphur was quoted on the local market at the end of February, 1919, at 40 francs per 100 kilos (220 lb.) bulk, minimum 3000 tons (no import tariff). The product, however, is used in the refined state and was quoted on the local market at 60 francs per 100 kilos, c. i. f. Bordeaux, in double sacks, minimum 2000 tons (import tariff, 3 francs per 100 kilos). The only refinery in this region is the Compagnie Europeene de Traitements des Minerais, Quai de Brazza, Bordeaux, a branch of a San Francisco firm, but it is now under requisition by the French Government. There are several sulphur refineries at Marseille and Cette.

Relatively, quite a large amount of sulphur was imported from the United States before the war, the American product being as good and at a better price than that from Italy.[2]

Following are the sulphur exports and imports of France for the past 6 years, in metric tons:

Year.	Exports.	Imports.
1913	23,324	186,344
1914	14,639	115,782
1915	11,608	99,395
1916	17,301	128,095
1917	5,532	76,866
1918	3,652	71,886

Japan.—According to the figures of the Japanese Department of Agriculture and Commerce, the production of sulphur in 1918 was 81-200 long tons. Compared with the output of last year there was a decrease of 34,920 tons, or 30 per cent.

The cause of this falling off is the tremendous advance in freight rates to Australia, the best customer for Japanese sulphur, purchasing about half of the quantity sold. The steamship companies have raised their freight rate to 95 yen (about $48) per ton, while they were charging 35

[1] *Salt Lake Min. Rev.*
[2] *Comm. Rept.*, May 5, 1919.

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yen last year. Therefore the price, c. i. f. Australian port, of sulphur selling at 55 yen per ton net in Japan would be more than 160 yen (including freight, marine insurance, war risk, and other charges), which is prohibitive. The merchants of Australia will not give any orders to Japan until the freight rates show some decrease. On the other hand, the customers of India, South Africa, and the South Sea Islands, having placed too many orders during last season, are not active at all now, and the market looks very quiet. About 35,000 tons of previous orders are ready for shipment, lying at the manufacturers' warehouses on account of the scarcity of bottoms. Under such circumstances some of the manufacturers are in a serious condition and some have even become bankrupt.[1]

Mexico.[2]—On the Huascamán estate, San Luis Potosi, there are a number of mines belonging to an American corporation, and sulphur is extracted at the rate of 800 tons per month and sold at an average price of 50 pesos per ton. The greater part is exported to Europe. In the Sierra de Banderas, Durango, there are other mines, which produce a large amount of sulphur which is sold to a neighboring dynamite factory. In the same locality there are still other mines, at present abandoned, but capable of production if developed. An advantage in this case is that they are near to railroads.

Sulphur has been mined in the district of Viesca, Durango, but the mines have not been developed to any extent. To the south of Venado, San Luis Potosi, there is a small property which has produced four tons a day. To the south of Guadalcázar, in the same state, there is a mine which produced 25 tons a month in 1913. About 80 kilometers from Matamoros, Tamaulipas, there is an important deposit. To the south of Calexico, Lower California, there are considerable quantities of sulphur which can be readily shipped to San Francisco and sold there for $12 per ton. Other deposits in Lower California are at Promontoria and Las Vírgenes.

Sicily.—A considerable increase is noticed in the exportation of sulphur from Catania for the year 1918. During that year 72,859 metric tons was exported as against 55,127 for the corresponding period of 1917. Of the sulphur shipments from Catania the largest amount went to continental Italy, with France, Algeria and Tunis, Portugal, England, and Spain following in the order named.

The total sulphur export for all of Sicily for the year 1918 was 230,769 metric tons as against 168,487 metric tons for 1917.[3]

[1] Weekly Bulletin, Canadian Department of Trade and Commerce, Ottawa, Aug. 19.
[2] *Eng. Min. Jour.*, Aug. 10, 1918.
[3] *Comm. Rept.*, Apr. 11, 1919.

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TOTAL EXPORTS OF SULPHUR FROM SICILY
(In metric tons)

Country.	1911.(d)	1912.(d)	1913.(d)	1914.(d)	1915.(d)	1916.(a)	1917.(a)	1918.(a)
Austria	34,136	38,362	36,335	25,306	70	.....	.....	.....
Belgium	11,771	10,723	13,321	5,975	.....	.....	.....	.....
France	114,868	104,109	21,582	60,773	96,156	107,311	68,565	.....
Germany	28,664	32,286	31,042	18,826	391	.....	.....	.....
Greece and Turkey	24,933	15,436	20,112	20,746	19,857	15,384	3,893	.....
Holland	10,549	14,019	8,976	8,080	1,163	524	.....	.....
Italy	72,959	84,952	85,740	97,170	116,601	76,502	53,748	.....
Portugal	25,121	21,314	21,445	17,604	21,004	13,994	5,749	.....
Spain						8,127	2,017	.....
Scandinavia (c)	29,741	35,111	28,108	25,294	24,832	26,450	2,500	.....
Russia	23,485	25,563	25,891	21,290	2,791	19,947	6,578	.....
United Kingdom	19,936	19,830	16,052	12,991	36,156	68,849	20,114	.....
United States	8,482	2,856	1,028	1,406	2,054	612	.....	.....
Other countries(b)	49,181	42,731	54,185	22,883	38,731	62,440	4,213	.....
								.....
Totals	453,826	447,292	414,717	338,344	359,806	396,035	168,487	230,769
Stock in Sicily, Dec. 31	551,442	450,917	376,365	369,001	274,069	155,376	156,801	112,050

(a) Statistics of the International Institute of Agriculture, Rome. (b) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (c) Including Norway, Sweden and Denmark. (d) Reported by Parsons & Petit, New York.

The report that accompanies the draft of the bill for granting an extension of 12 years to the syndicate interested in the sulphur production of Sicily intimates that such extension has been asked for in order to protect the principal industry of Sicily, which is confronted with greater foreign competition at a time when not only larger quantities of the product are needed for explosives but labor for working the mines is scarce. It is believed that the intensifying of the Japanese production, the discovery of deposits in northern Africa, and the very considerable American output constitute a serious menace to the native industry. In view of the situation, therefore, it is believed that by extending for 12 years the rights of the syndicate, whose special work it is to combine and regulate the efforts of the individual producers, efficient means will be adopted for meeting the competition of the future.[1]

The total Italian production for the past few years is as follows:

	Metric Tons.
1913	386,310
1914	377,843
1915	358,107
1916	269,374
1917	211,847

Spain.—The Spanish Government by royal order, published on Dec. 3, 1918, constituted a special committee for the importation of sulphur and its distribution throughout the markets of the Kingdom.

[1] Weekly Bulletin, Canadian Department of Trade and Commerce, Ottawa, July 22.

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PYRITE

IMPORT RESTRICTIONS

Early in the year pyrite was included in the list of materials to be imported in restricted quantities. The limit set for pyrite was 125,000 long tons to Oct. 1, 1918, to be distributed as follows: April, 40,000 tons; May, 30,000; June, 20,000; July, 15,000; August, 10,000; September, 10,000 tons. Restrictions were entirely removed on Jan. 16, 1919.

The following table shows the source of the monthly receipts during 1918, in long tons.

	Spain.	Canada.	Total.
January	38,607	2,559	41,166
February	50,795	2,592	55,346
March	49,566	1,540	51,276
April	34,255	3,442	37,697
May	23,406	15,998	39,404
June	13,881	17,291	31,172
July	11,905	34,503	46,908
August	15,364	41,469	57,420
September	4,349	43,623	50,651
October	.....	35,051	35,051
November	.....	20,975	21,775
December	24,222	2,399	26,621
Total	270,649	221,442	498,786

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1904	173,221	$669,124	413,585	$1,533,564	586,806	$2,202,688
1905	224,980	752,936	515,722	1,780,800	740,702	2,533,736
1906	225,045	767,866	597,347	2,138,746	822,392	2,906,612
1907	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910	223,700	830,150	806,590	2,773,627	1,030,290	3,603,777
1911	299,904	1,150,597	1,001,944	3,788,632	1,301,848	4,939,229
1912	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913	341,338	1,286,284	850,592	3,611,136	1,192,930	4,897,421
1914	336,662	1,283,346	1,026,617	4,797,326	1,363,279	6,080,672
1915	394,124	1,374,933	964,634	4,817,977	1,358,758	6,492,910
1916	423,556	1,965,702	1,244,519	6,728,318	1,668,218	8,694,020
1917	462,662	2,485,435	967,340	5,980,457	1,430,002	8,465,892
1918	455,432	2,903,786	498,786	2,767,448	954,218	5,671,234

(a) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (b) Net imports, less re-exports.
U. S. Geological Survey.

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WORLD'S PRODUCTION OF PYRITE
(In metric tons)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Greece.	Hungary.	Italy. (a)
1903..	720	6,589	30,822	9,794	322,113	170,867	*Nil.*	96,619	101,455
1904..	1,075	10,421	29,980	10,452	271,544	174,782	*Nil.*	97,148	112,004
1905..	976	19,045	29,713	12,381	267,114	185,368	*Nil.*	106,848	117,667
1906..	908	13,474	35,927	11,318	265,261	196,971	*Nil.*	112,623	122,364
1907..	397	3,671	35,494	10,357	283,000	196,320	*Nil.*	99,503	126,925
1908..	357	10,403	42,934	9,599	284,717	219,455	6,868	95,824	131,721
1909..	214	7,266	58,645	8,564	273,221	198,688	14,740	98,971	149,084
1910..	213	571	48,871	10,393	250,432	215,708	33,294	92,464	165,688
1911..	122	3,118	74,978	10,276	277,900	217,459	35,960	96,754	165,273
1912..	148	6,216	73,944	10,691	282,202	242,121	29,766	103,809	277,585
1913..	268	3,242	143,882	11,611	311,167	(g)228,405	128,880	106,629	317,334
1914..	109	4,459	204,125	11,848	(b)	(b)	129,150	102,370	335,531
1915..	129	(b)	259,494	10,711	(b)	(b)	12,113	(b)	369,320
1916..	212	(b)	280,552	10,656	(b)	(b)	19,938	(b)	410,290
1917..	81	(b)	365,821	8,652	(b)	(b)	(b)	(b)	500,782

Year.	Japan.	Newfound-land.	Norway. (c)	Portugal. (c)	Russia.	Spain.	Sweden.	United States.	Total.
1903 ..	16,149	42,674	129,939	376,177	22,780	155,739	7,793	202,577	1,692,812
1904 ..	24,886	61,166	133,603	383,581	31,667	161,841	15,957	175,992	1,696,099
1905 ..	25,569	51,534	162,012	352,479	30,689	179,079	20,762	228,580	1,789,816
1906 ..	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907 ..	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908 ..	33,867	(e)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,780,436
1909 ..	27,066	*Nil.*	282,606	284,735	46,078	236,000	16,104	213,371	1,915,353
1910 ..	78,418	*Nil.*	322,000	312,906	55,980	294,184	25,445	227,280	1,860,148
1911 ..	73,879	2,500	350,000	282,773	113,054	344,879	30,096	304,974	2,383,995
1912 ..	74,929	*Nil.*	469,326	(f)601,443	123,990	421,070	31,835	356,707	3,105,782
1913 ..	114,589	.....	441,219	(f)391,083	e)130,000	926,913	34,319	347,027	3,636,478
1914 ..	115,842	.....	414,886	(a) 73,404	(b)	(b)	33,313	342,082	3,145,000
1915 ..	67,536	.....	513,335	(b)	(b)	730,568	76,324	399,469	.....
1916 ..	91,102	.....	300,000	(b)	(b,	953,679	97,848	430,615	.....
1917 ..	121,349	.....	(b)	(b)	(b)	2,194,757	142,366	470,373	.....

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (e) Estimated. (f) Includes 120,148 tons copper iron pyrite in 1912 and 13,550 tons in 1913. (g) Prussia alone.

Canada.—The shipments of pyrite as sulphur ore from Canadian mines were about 3000 tons less in 1918 than 1917. The total shipments during the past year were 413,698 tons valued at $1,688,991 and included 124,871 tons valued at $507,802 from the province of Quebec; 270,589 tons valued at $1,117,735 from the province of Ontario; and 18,238 tons valued at $63,454 from the province of British Columbia. The total sulphur content of shipments was 157,311 tons, or an average of 38 per cent. Of the total shipments 85,951 tons was sold for consumption in Canada and 327,747 tons for consumption in the United States.

In 1917 the total shipments were 416,649 tons valued at $1,610,762, or by provinces, as follows: Quebec, 122,882 tons valued at $501,351; Ontario, 288,058 tons valued at $1,080,866; and British Columbia, 5709 tons valued at $28,545. The total sulphur content of the year's shipments was 155,163 tons, or an average of 37.2 per cent., the ores from different properties varying from 29 to 48.6 per cent. in sulphur. Of the total shipments in 1917 about 49,320 tons was sold for consumption in Canada and 367,329 tons for export to the United States.

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It had been anticipated during the early part of the year that the production of pyrite during 1918 would considerably exceed that of the previous year, but labor shortage, transportation difficulties, high cost of supplies and other causes prevented this realization.

The principal shipments were obtained as usual from the same sources as in previous years. In Quebec, practically the same tonnage of cupriferous ores was shipped from the Eustis and Weedon mines in the Eastern Townships. In Ontario the largest shippers for export were the mines at Goudreau on the Algoma Central Railway in Michipicoten district and at North Pines on the Canadian National Railway, northwest of Port Arthur. Mines shipping for domestic consumption were the Helen in Michipicoten, the Sulphide, Queensboro, Craig, Clyde Lake and Bannockburn in Central Ontario; additional trial shipments of car lots were made from three other properties. In British Columbia shipments were made from the Sullivan mine at Kimberley to the sulphuric-acid plant at Trail and from Anyox to the acid plant at Barnet, B.C.

Customs records show exports of pyrite during 1918 as 240,453 tons valued at $949,067, as compared with exports in 1917 of 279,646 tons valued at $974,200. These figures are much less than those reported directly by the operators and it is possible that some of the exports from Quebec may be entered as a copper ore.[1]

Norway.—The purchase, by the State, of the Grong sulphur ore deposits for the sum of 10,593,000 kroner was recently sanctioned by the Norwegian Diet.[2] The Grong mines are at present under the management of the Electrochemical Industry Co., and the more important deposits within the group are the Joma, the Gjersvik and the Skorovas. The Joma deposits are said to contain 6,500,000 tons of ore, most of it carrying 44 to 45 per cent. sulphur and a little copper. The Skorovas deposits contain at least 1,000,000 tons, almost entirely free from copper, having 50 to 51 per cent. sulphur, and free from arsenic. The Gjersvik deposits are estimated to contain about 1,200,000 tons of ore containing 2.2 per cent. copper and about 42 per cent. sulphur. Thus the aggregate content of the Grong mines is at least 8,500,000 tons. When the transport arrangements have been completed, the annual output should amount to about 400,000 tons. The shares of the Grong mines were principally in French hands.

Advices from Norway state that an agreement has been made between the Rio Tinto Co. and the Union of Exporters of Norwegian pyrite whereby any excess of Norwegian output after requirements of neutrals

[1] Prelim. Rept. Min. Prod. of Canada, Can. Dept. of Mines.
[2] *Chemical Trade Journal and Chemical Engineer.*

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have been satisfied will be reserved for the Rio Tinto Co. until the end of the war, or up to December 31, 1919, if the war should last till then.[1]

Spain.—The Province of Huelva, Spain, is the greatest producer of pyrite in the world. There still exists, according to the calculations of mining experts, about 250,000,000 tons, of which the present exportation is about 3,000,000 tons per annum. In normal times the United States takes 1,000,000 tons; in 1917 the tonnage reached was 755,991 only, from the following mines: Rio Tinto, Tharsis, and Esperanza (British), 614,317 tons; Perrunal and San Platon (French), 122,091 tons; and La Joya (Spanish), 19,583 tons.[2]

Although exports of ore from Rio Tinto have materially decreased since the war, local production is still maintained. The 1918 production amounted to 13,000 metric tons of blister copper and 9000 tons of precipitate, as compared with 12,000 tons of blister and 6000 tons of precipitate in 1914.

The pyrite output has had a serious setback for want of ships. For this reason, operations have been very irregular and difficult. Rio Tinto and most of the other mines have had to reduce the number of men employed, and this reduction is becoming more acute of late.[3]

Sulphuric Acid

The dislocation of world trade and commerce by the war had its effect on sulphuric-acid production, and for a time the uncertainty of a ready supply of sulphur was disquieting. Our sulphuric-acid industry had been built up largely on the use of pyrites imported from Spain. Thus in 1912 we imported 970,785 long tons of pyrites containing more than 25 per cent. of sulphur; in 1913, 850,592 tons; in 1914, 1,026,617. This high mark was followed by a slump in 1915 to 964,634 tons; and this, in turn, by a rise to 1,244,662 tons. In 1917 the imports fell off to the level of 1912 and 1915, amounting to only 967,340 tons.

With these disturbances it became necessary to readjust our industry to the use of domestic sulphur-bearing materials and in some cases to remodel plants to burn native sulphur in place of pyrites. There was a wide search for sulphur-bearing ores throughout the United States, and while it can be said that we have ample supplies of sulphur-bearing ores, this does not easily solve the problem of acid production. There has been reluctance to use certain ores, notably pyrrhotite, on account of the changes in practice which would be involved. Regardless of these difficulties, however, and the further problems of labor shortage and transportation, the industry has served the warring nations with remarkable ability.[4]

[1] *Metal Bull.*, Aug. 9, 1918.
[2] *Comm. Rept.*, June 12, 1918.
[3] *Min. Mag.*, Sept., 1918.
[4] *Chem. Met. Eng.*, Sept. 25, 1918.

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A report on the present sulphuric-acid capacity of plants in the United States and on the requirements for 1919 has been made to the Chemical Alliance by Arthur E. Wells, who is one of the sulphuric-acid specialists of the War Industries Board. The report reads as follows:

On Jan. 1, 1918, the total manufacturing capacity of the country for acid was 427,000 tons per month (basis 100 per cent. H_2SO_4), or 8,200,000 tons per year (basis 50° Bé.), of which 29 per cent. was at contact acid plants.

On Nov. 1 of this year, the total manufacturing capacity of the country was 500,000 tons per month (basis 100 per cent. H_2SO_4), or 9,600,000 tons per year (basis 50° Bé.). Of this total capacity 40 per cent. was at contact acid plants.

This capacity was divided among (1) Government, (2) explosives companies, (3) all others, including commercial manufacturers and by-product manufacturers, as follows:

SULPHURIC ACID MANUFACTURING CAPACITY OF UNITED STATES

	Expressed as Tons per Month, 100 Per Cent. H_2SO_4	Expressed as Tons per Year, 50° Bé.
(1) At Government plants	54,000	1,040,000
(2) At plants of explosives manufacturers	58,000	1,120,000
(3) All others	388,000	7,440,000
Totals	500,000	9,600,000

The total capacity east of the Mississippi River, and also including the plant at Argentine, Kan., and the plants in Louisiana and Arkansas, is 454,000 tons per month as 100 per cent. H_2SO_4. The report continues:

If it be assumed that the Government plants and the contact plants, which were built by the explosives companies primarily to supply acid for munitions explosives, are not operated in 1919, or, if operated at all, that the production will be utilized only for munitions, and thus will not be placed on the market, there remains a total capacity to be considered in the eastern part of the United States amounting to 365,000 tons per month (basis 100 per cent. H_2SO_4), or 7,000,000 tons per year (basis 50° Bé.).

During the first nine months of 1918 the actual rate of production was only about 90 per cent. of the rated maximum capacity, although many plants were operating much above the rate capacities. Therefore, it is fair to conclude that the probable maximum output from these plants for 1919 cannot be greater than 90 per cent. of the rated capacity, or, in other words, the maximum output could be only about 328,000 tons per month (basis 100 per cent. H_2SO_4), or 6,300,000 tons per year (basis 50° Bé.).[1]

Although the acid production in this country has increased largely during the last four years, manufacturers do not anticipate that any great difficulties will be experienced in readjusting themselves to new conditions. Many of those who under normal conditions produced acid as a by-product, such as the Eastern zinc and copper smelters, found it desirable, in view of the enormous demand, to increase their output considerably by the use of brimstone. All such brimstone acid-making can readily be discontinued. There were also numerous plants operated by the Government direct, and these too will undoubtedly be discon-

[1] *Eng. Min. Jour.*, Dec. 28, 1918.

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tinued. It is not unlikely that many of the smaller producers who were attracted by the possibilities of the acid business for explosives, etc., during 1918, and who were able to operate successfully under the prevailing prices, will find themselves compelled gradually to curtail their production. In view of these factors, therefore, all of which operate toward a reduced production, and because of the further important fact that numerous uses for sulphuric acid, which bid fair to become increasingly important as time goes on, have grown up out of the war, there is a feeling that the acid market will soon adjust itself to a stable position.

In 1915–16, sulphuric acid of 60° Bé., which in pre-war times realized about $6 to $8 per ton, sold at $50 and $60 per ton. Before the end of 1916 the price had receded practically to the pre-war normal. The price of $7 and $8 per ton at that time was undoubtedly subnormal, considering increased cost of production. At the beginning of 1917 the market was $12 and $13, and even that was regarded as low. It advanced during 1917 and was quoted at $22 and $25 at the close of the year. The recent price in the open market has been about $25.

The War Industries Board announced on June 27 that, as a result of a meeting of the manufacturers of sulphuric acid with the price-fixing committee of the War Industries Board, maximum prices were agreed upon and approved by the President, taking effect immediately, and expiring on Sept. 30, 1918, as follows:

Sulphuric acid 60° Bé., $18 a ton of 2000 pounds.

Sulphuric acid 66° Bé., $28 a ton of 2000 pounds.

Sulphuric acid 20 per cent. oleum, $32 a ton of 2000 pounds.

Free on board manufacturer's works in seller's tank cars.

In carboys in carload lots, ½ ct. a pound extra.

In carboys in less than carloads, ¾ ct. a pound extra.

In drums, any quantity, ¼ ct. a pound extra.

These prices were changed on Sept. 30 to $16 for 60° Bé. and $25 for 66° Bé.[1]

PRODUCTION OF SULPHURIC ACID FROM COPPER AND ZINC SMELTERS, 1916–1917 IN SHORT TONS

(Figures of the U. S. Geological Survey)

Source.	1916.			1917.		
	Quantity.	Value.	Price Per Ton.	Quantity.	Value.	Price Per Ton.
Copper smelters, 60°.....	398,004	$3,988,615	$10.02	427,646	$3,254,962	$7.61
Zinc smelters, 60°.....	671,585	8,169,651	12.16	908,563	11,261,142	12.39
Stronger acids.....	92,802	1,941,661	20.92	119,048	2,374,441	19.94
Total.....	1,162,391	14,099,927	12.13	1,455,257	16,890,545	11 63
60° acid reduced to 50° Baumé.....	1,347,082	.....	.....	1,683,823	.....	.....

[1] *Eng. Min. Jour.*, Jan. 11, 1919.

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PRODUCTION OF SULPHURIC ACID IN THE UNITED STATES IN 1916 AND 1917, BY GRADES IN SHORT TONS
(Figures of the U. S. Geological Survey)

Grade.	1916.			1917.		
	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.
50° Baumé	1,829,471	$17,484,273	$9.55	2,199,224	$30,552,396	$13.89
60° Baumé	1,119,753	12,362,884	11.04	1,350,416	15,129,343	11.20
66° Baumé	1,580,100	32,860,212	20.80	1,359,739	25,823,797	18.99
Stronger grades	443,332	10,806,757	24.38	759,039	16,034,645	21.12
Total	4,972,656	73,514,126	14.79	5,668,418	87,540,181	15.44
Total reduced to 50° Baumé acid	(a) 5,642,112	(a) 62,707,369	(a)11.11	(a)5,967,511	(a) 71,505,536	(d)11.98

(a) Exclusive of stronger acids.

Germany.—During the war American chemists were puzzled as to the source of the enormous amount of sulphuric acid which the Germans were able to secure. Information is now in the hands of the Bureau of Mines showing that at no time during the war was there any particular stringency in Germany's supply of this acid. During the early months of the war, before conventions could be made with neutral countries, large shipments of pyrite were made to Germany. In fact, importation of pyrites into Germany continued in some volume throughout the war. The large reserve built up at the beginning of the war gave Germany time to find new resources of sulphuric acid. A noteworthy development of the Meggen pyrite deposits took place. Other pyrite beds were opened in Germany and Hungary, and a considerable amount of sulphur was obtained from Asia Minor.

In addition, Germany made important use of its rich beds of blende and galena. A method was evolved by which the lead dust, which had been a source of trouble in the contact process of manufacture, was eliminated. In addition, kaiserite and plaster of paris provided sources of sulphuric acid. Some sulphur was obtained by purifying gas at coke plants.

As a matter of fact, sulphuric acid was so plentiful in Germany toward the close of the war that restrictions on its use in industrial plants were rapidly being lifted.[1]

Great Britain.—The annual production of sulphuric acid in the British Isles before the war was about 1,000,000 tons per annum as 100-per cent. acid (equal to 1,500,000 tons of chamber acid). This quantity may also

[1] *Eng. Min. Jour.*, Apr. 26, 1919.

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be taken as the national consumption, since both the export and import of sulphuric acid were negligible in amount.[1]

The producing plant was almost entirely of the lead-chamber type. The demand for concentrated acid was very small and was met by three firms employing contact plants producing about 22,000 tons per annum for explosives and dye manufacture and by concentrating plants, which were producing from chamber acid some 75,000 tons of 95-per cent. acid. The large consuming trades throughout the country were users of chamber acid.

The national productive capacity before the war is difficult to estimate, but it was certainly considerably larger than the actual output. This was largely a result of the seasonal nature of the demand for sulphuric acid for fertilizer manufacture. It was the general practice of manufacturers of acid for superphosphate production to lay off their plants for repairs during a part of each summer season. Acid plants generally were also worked less intensively before the war than has been the case in the war period, when the maximum of output has been aimed at. The acid manufacturers were for these reasons able to increase the production of sulphuric acid by at least 10 per cent. without addition to existing plant when increased production was required.

The enormous demand for sulphuric acid of high strength for explosives manufacture has led to far-reaching changes in the sulphuric-acid industry. In the earlier stages of the war these requirements were mainly met by the construction of concentrating plants on a large scale. The chamber acid for concentration in these plants was obtained partly by more intensive working of the plants and partly by restriction of supplies for superphosphate manufacture and for certain purposes, such as grease recovery and metal pickling, for which niter cake was used as a substitute. Importation of oleum from America was also undertaken on a considerable scale. These measures were, however, insufficient to meet the growing requirements, and a policy of new construction was entered upon. Large oleum plants were constructed in connection with Government explosives factories, and at the same time private manufacturers were encouraged to extend their chamber and concentrating plants. As a result the productive capacity of the country has reached a figure far in excess of the pre-war consumption and has created a post-war problem of considerable difficulty.

Allowing for a post-war reversion to normal working conditions the post-war position is estimated to be, in tons of 100-per cent. acid: oleum —pre-war 22,000, post-war 450,000; chamber—pre-war 1,040,000, post-war 1,265,000; total—pre-war 1,062,000, post-war 1,715,000; equiva-

[1] *Comm. Rept.*, Apr. 17, 1919.

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lent chamber acid—pre-war 1,593,000 tons, post-war 2,572,000 tons; giving a gross surplus of 653,000 tons of 100-per cent. acid or 979,000 tons of chamber acid per annum. This estimate is based upon the assumption that all plant at present under construction will in fact be completed and that no scrapping of plant takes place. On both these grounds the estimate may require to be diminished, and the figure 653,000 may for this reason be taken as a maximum estimate.

The productive capacity of acid plant, either owned or leased by the Ministry of Munitions, is estimated at 315,000 tons of 100-per cent. acid (equivalent to 472,000 tons of chamber acid) per annum, or rather less than half the gross estimated surplus. Practically the whole of the Government plant is of the contact type.

The following is a list of acid factories owned or leased by the Government, with their output of 100-per cent. acid in tons per annum:

	Tons.
A. Oleum plants erected during the war:	
H. M. Factory, Avonmouth, 10 Grillos	89,200
H. M. Factory, Queen's Ferry, 10 Mannheims, 10 Grillos	111,500
H. M. Factory, Gretna, 8 Mannheims, 4 Grillos	53,500
R. N. Cordite Factory, Poole, 2 Tentelew	8,900
H. M. Factory, Oldbury, 2 Mannheims	4,500
H. M. Factory, Pembrey, 6 Tentelow	26,700
S. Metropolitan Gas Co., 1 Grillo	8,900
Total	303,200
B. Chamber plants leased by H. M. Government:	
H. M. Factory, West Gorton	6,200
Dalton Main Collieries	5,200
Total	11,400
Total acid under Government management	314,600

The British Minister of Munitions ordered that from June 1 the maximum prices for sulphuric acid specified below will be substituted for those specified in the schedule to the order dated May 29, 1917:

1. Weak acid; that is, acid of all strengths up to and including 90 per cent. H_2SO_4:

Class A.—Arsenical acid, maximum price per ton, 83s. ($19.70), for acid of 140° Twaddell at 60° F., with an increase or reduction of 6d. (12 cts.) in respect of each complete degree Twaddell by which the specific gravity is more or less than 140° Twaddell at 60° F.

Class B.—Non-arsenical or de-arsenicated acid, maximum price per ton, 98s. ($23.27), for acid of 140° Twaddell at 60° F., with an increase or reduction of 7d. (14 cts.) in respect of each complete degree Twaddell by which the specific gravity is more or less than 140° Twaddell at 60° F.

2. Concentrated acid; that is, acid of all strengths over 90 per cent. H_2SO_4:

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Monohydrate Content of Acid, Per Cent.	Maximum Price Per Ton.							
	Class C.				Class D.			
	Arsenical Acid.			U. S. Currency.	De-arsenicated or Non-arsenical Acid.			U. S. Currency.
	£	s.	d.		£	s.	d.	
90 to 91	5	9	0	$25.90	5	19	0	$28.25
91 to 92	5	15	0	27.30	6	5	0	29.70
92 to 93	6	1	0	28.75	6	11	0	31.10
92 to 93½	6	7	0	30.15	6	17	0	32.55
93½ to 94	6	10	0	30.90	7	0	0	33.25
94 to 94½	6	13	0	31.60	7	3	0	33.95
94½ to 95	6	16	0	32.30	7	6	0	34.70
95 to 95½	7	1	0	33.50	7	11	0	35.85
95½ to 96	7	6	0	34.70	7	16	0	37.05

Over 95 per cent. in both classes, an addition of 1s. (24 cts.) per ton, for each complete one-tenth of 1 per cent. of additional monohydrate.[1]

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[1] *Eng. Min. Jour.*, Aug. 17, 1918.

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TALC AND SOAPSTONE

By Frederick B. Peck

It is true that there are few if any other minerals that are used for such a variety of purposes as are talc and soapstone. They are indeed indispensable to our twentieth century civilization and their uses and production are increasing, and undoubtedly will continue to increase for some decades to come. In fact we may regard the industry as still in its infancy.

The most recent indication of an expansion of the talc industry in the United States is to be found in the increased activity of the talc production of the State of Vermont. During 1917 and 1918 up to the time of the signing of the armistice, the Vermont talc industry was extremely active, all of the producers working to capacity. Approximately 70 per cent. of the production of Vermont was mined and manu-

PRODUCTION OF TALC AND SOAPSTONE BY STATES

	1913.		1914.		1915. (b)		1916. (b)		1917. (b)	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
New York	81,705	$788,500	86,075	$821,286	88,214	$864,843	93,286	$961,510	74,671	$881,462
Vermont..	45,547	327,375	50,698	363,465	61,997	406,652	73,215	501,175	93,960	625,150
Virginia...	26,487	615,558	21,687	527,938	3,036	18,579	8,798	73,622	6,432	85,856
N. J. and Pa.	11,308	80,780	7,732	54,549	7,989	56,466	8,222	59,331	.....	.....
North Carolina	4,676	48,817	1,198	28,413	1,454	21,501	1,787	41,824	2,175	41,766
California	952	6,000	547	8,786	712	7,185	1,130	13,694	4,152	74,000
Georgia	.....	.....	.....	.....	498	12,050	6,921	111,686	3,819	94,314
Other States	5,158	41,067	4,359	60,650	2,786	15,143	(a)	(a)	13,404	87,124
Total...	175,833	$1,908,097	172,296	$1,865,087	166,636	$1,401,197	193,309	$1,762,842	198,613	$1,889,672

(a) Massachusetts included with Georgia, Maryland with California. (b) Talc only.

Talc only	Georgia, California and New York.
Talc and soapstone	North Carolina, Vermont and Virginia.
Talc and serpentine	New Jersey and Pennsylvania.
Soapstone only	Rhode Island.
Pyrophyllite	North Carolina.

factured by the Eastern Talc Co., the remainder of the production being furnished by the American Mineral Co., Magnesia Talc Co., Vermont Talc Co. and one or two smaller producers. Prices of the lower grades of talc averaged from 15 to 20 per cent. above those previously prevailing, while in the higher grades advances ranged as high as 25 per cent. These

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advances have not entirely covered the increased cost of labor and supplies so that contracts for 1918 were made at advanced figures. The Eastern Talc Co., at Rochester, Vt., is now developing a large body found by diamond drilling near the Williams mine. Heretofore New York has always been the first state in quantity and value of talc produced, but in 1917 its output was less than that of Vermont, although on account of the fibrous character of the talc produced in New York and its consequent high value for making paper, the total value of the output in New York is still greater than that of any other talc-producing state. During 1918 the production of talc in New England amounted to approximately 78,000 tons, an increase of 5 per cent. over previously reported amounts, and an increase of nearly 15 per cent. over the production of 1915. Vermont is also a soapstone-producing state. No actual figures are available on soapstone slabs and ground soapstone produced here, but the output for 1918 will in all probability fall below that of 1917.

Another section of the United States that is beginning to make itself felt as a talc producer is western Nevada. According to statements made by W. B. Hinchman,[1] assistant traffic manager of the Tonopah and Tidewater Railroad, three talc mines have been opened up about 4 miles from the stations of Acme and Riggs, and the business is expanding so rapidly that a new station is to be created, called Talc, to improve the shipping facilities of the new industry. These talc mines rank with the largest producers in the country, turning out 300 to 400 tons of high-grade talc each week, most of which goes to New York and Chicago to be manufactured into talcum powder. Other concerns that absorb part of the product of the mines are the Eisenmayer-Main-Crain Company of Los Angeles, the Pacific Tile and Terra Cotta Company of Torpico, Calif., and the American Steel and Wire Company, Joliet, Illinois. At the present rate of development the talc industry here promises to be one of the really important ones of western Nevada. The quarries are operated by open-cut methods, the rock being first shot down and then handled with steam shovels. The Western White Talc Company is the largest shipper. At present the rock is being conveyed by motor trucks to the railroad. The statement is made that nine-tenths of the talcum powder at present being made in this country is manufactured from the product of these quarries.

The demand for talc during the year 1918 was greater than ever before, chiefly because of the shortage of French and Italian importations, and because of the inability to secure English China clay, which is used in this country as a substitute for talc in the manufacture of paper. A

[1] *Mining American*, Sept. 16, 1918.

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number of cotton cloth manufacturers, who formerly used only the imported varieties of talc (Italian and French) have found certain domestic grades satisfactory, and in all probability, having once adjusted themselves to the use of the home product, they will continue to use it even after foreign importations are resumed and pre-war conditions and prices become again established. Several large paper mills, which manufacture superior grades of book and writing papers, are also using domestic talc instead of English China clay, and in all probability they will not return to the use of the imported material. In addition to these new uses of our domestic product, the larger demand for talc in the increased manufacture of rubber goods and prepared roofing is still further expanding the horizon of our native talc industry.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES
(In tons of 2000 lb.)

	U. S. (a)	France. (b)	Italy. (c)	Canada. (c)	Spain. (d)	Austria. (e)	Ger. Empire, Bavaria. (d)
1908	117,354	37,053	12,048	1,016	5,214	.....	2,424
1909	130,338	38,433	13,228	4,350	6,154	.....	2,537
1910	150,716	42,316	13,727	7,112	5,143	.....	3,308
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,728
1912	159,270	60,629	15,800	8,270	(e)	(e)	3,551
1913	175,833	(e)	26,456	12,250	(e)	(e)	(e)
1914	172,296	(e)	24,777	10,808	(e)	(e)	(e)
1915	186,891	(e)	24,187	11,885	3,925	(e)	(e)
1916	212,961	(e)	30,294	11,810	1,062	(e)	(e)
1917	218,848	(e)	24,100	15,803	3,803	(e)	(e)

(a) Talc and soapstone. (b) Talc, soapstone and asbestos. (c) Talc. (d) Soapstone. (e) Statistics not available.

The United States in 1917 produced 198,613 tons, which was valued at $1,889,672, an average of $9.51 per ton. This was an increase of 3 per cent. in quantity and 7 per cent. in value over the output of 1916. The final figures for 1918 show a total production of 192,817 ton, valued at $2,107,683, of which 13,133 tons was crude, 945 tons manufactured and 178,739 tons ground. The production of soapstone in 1918 was 13,995 nons, as compared with 20,235 tons in 1917. During the ear 1918 prices advanced from 12 to 20 per cent. over those of 1917, varying with the various grades. The highest average prices for the best grades of manufactured articles ranged from $60 to $240 per ton, while the crude unmanufactured product ranged from $3.25 to $9.25 per ton, though the subsequent grinding of some of this crude talc raised its value to $10.50 per ton. While the prices of the various kinds of talc products have steadily advanced since 1916, chiefly on account of the increased cost of labor and materials, it is to be noted that this increase is less proportionately than of the other materials with which it is combined in the manufacture of such commodities as rubber and paper goods.

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Labor conditions were generally reported to be unsatisfactory during 1918, but were not of such a serious character as to cause numerous or protracted shut-downs, although the irregularity of labor has at times seriously interfered with production, and in the early part of 1918 some of the mills were closed, owing chiefly to car shortage, which made it impossible for producers to market their product.

Although, as previously stated, the manufacture of prepared talc in the United States is still in its infancy, and methods of manufacture are on the whole somewhat primitive and undeveloped, nevertheless many improvements have been made in separating the pulverized product, and it is because of this fact that paper and other manufacturers are becoming more interested in domestic talcs. Though no new processes of preparing talc for the market were developed in 1918, those already in vogue have been so standardized and refined that some producers have succeeded in obtaining a superior product, particularly during the last 2 years.

IMPORTS INTO THE UNITED STATES OF TALC, GROUND OR PREPARED (POUNDS)
(Fiscal years ending June 30)

Source.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Austria	1,281,884	1,101,611	1,064,429	807,364	.....	.....	.....
Belgium	18,937	13,200	2,500	.....	.....	.....	.....
France	7,928,761	8,593,706	12,138,883	4,845,928	8,586,686	5,599,605	751,670
Germany	937,591	16,407	56,345	86,400	.....	.....	.....
Italy	8,078,215	8,870,875	8,838,858	13,819,223	14,347,386	13,298,942	2,814,477
England	207,200	66,080	128,858	57,792	.....	112,492	.....
Canada	2,804,223	5,329,244	7,296,348	10,789,271	10,443,285	15,073,759	23,772,600
Other countries	.....	2,100	10,890	5,189	.....	218,245	87,240
Total	21,256,811	23,993,223	29,537,111	30,411,167	33,377,357	34,303,043	27,425,987

Importations of talc into the United States from European countries, particularly France and Italy, during 1918 were considerably curtailed, as one might surmise, by reason of the greatly disturbed condition of ocean transportation and the enormously increased freight rates. Our near neighbor, Canada, however, who during the war has more than held her own in the production of minerals, has been keeping the talc quarries at Madoc, Ontario (40 miles north of Lake Ontario and midway between Toronto and Ottawa) in rather brisk operation, and when the figures are available we believe they will show an increased production, as well as an increase in imports from Canada to the United States.[1]

In pre-war times the talc-producing countries of the world, named in the order of their importance, were United States, France, Italy, Austria-Hungary, Canada, Bavaria, and Norway. Since the outbreak of the

[1] Figures available later, from the Canadian Department of Mines, give the 1918 production of talc in Canada as 18,190 short tons, valued at $112,727, compared with the 1917 output of 15,803 tons, valued at $76,539.

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war another country has been added to the list, which promises to be a steady and important contributor to the world's talc production. This is South Africa.

In Zululand, near Pomeroy on the Maceheko River, the Buffalo Asbestos Company is producing ground talc, suitable for covering boilers and steam pipes, from a talc-tremolite rock. Massive talc is reported to be a common mineral in the crystalline rocks of Southern Rhodesia. Both fibrous and foliated talc are said to occur there. At Johannesburg in the Transvaal, talc is being prepared from talc schists, said to occur in pre-Cambrian rocks north of Krugersdorp. But the most important talc-producing section in this part of the world is the Barberton district. Here operations have been confined to what is known as the Verdite mine, located 3 miles northwest of Noordkaap Station on the Barberton railway. An account of the occurrence of the mineral there and a description of the method of preparing the talc are to be found in the June, 1918, number of the *South African Journal of Industries*. The article was prepared by Dr. Percy A. Wagner. A summary of the article is also given in the October number of the *Mining Magazine*. According to this writer, the talc occurs in bands having a maximum thickness of 15 feet and a nearly vertical dip. These bands are separated from the country rock by distinct joint (or fault) planes. The country rock is a grayish or greenish ultrabasic rock, rich in magnesia (probably peridotite), belonging to the Jamestown series. The best grade of talc rock is pale green in color, sub-translucent and distinctly fibrous in texture. The inferior grades are dark green in color and opaque. Gold occurs in thin films on the joint planes and the deposits were originally exploited for the gold. At present, however, the gold is a by-product of the talc-mining operations.

The amount of mineable talc is reported to be enormous. At present the mine developments consist of two shafts and drifts. The process of manufacture is as follows. At the plant the two or three grades of prepared talc receive separate treatment. The first grade after crushing to small size is passed to a disintegrator of the cyclone type, where it is reduced to a pulp. By means of a blower attached to the disintegrator the powdered rock is blown into a vertical elevator pipe, which communicates with a vertical sausage-shaped canvas balloon, into which the finest of the powdered rock is blown and from which it settles into a receiver below. The material thus collected constitutes the first grade of prepared talc and is used chiefly for toilet and medicinal purposes. Its color, however, is not quite white. The coarser talc, which does not find its way upward into the balloon, is carried by a side pipe to a fine horizontal silk screen and is sifted. The material remaining on the screen is

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reground. That which passes the screen constitutes the second grade of talc and is used for cleaning cereals, in the manufacture of soap and lubricants, as facings in brass foundries and by farmers in treating wounds and skin diseases of cattle. The part that remains on the screen is passed through a stamp mill, on emerging from which the free gold is separated by amalgamation, and the tailing after passing over Wilfley tables is dried and screened. The material thus obtained is used in leather dressing and finishing, in paint and rubber manufacture, by automobile garages, as a preservative of fruit and eggs and in the manufacture of imitation stone and tiles. Some of the crude rock material is sawn into slabs or manufactured into gas tips, slate pencils and engineers' pencils. The product of the Verdite mine in 1917 amounted to 715 tons of crude talc, valued at 1962 pounds sterling, and 412 tons of manufactured articles valued at 3485 pounds sterling. The Barberton talc deposits furnish the basis for a new and prosperous industry the product of which even during the war has been finding its way to England and the United States and under the stress of war conditions has developed into a concern that will in the future figure in the world's production of talc.

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TIN

By Baliol Scott

1918 was the most sensational year in the tin industry that has ever been recorded, but despite that there are few producers outside Bolivia who will look back to it with pleasant feelings. The industry suffered practically throughout the year from incessant interference of every kind —shortage of labor, shortage of plant and supplies, demands for wages in correspondence with the great advance in prices—but beyond and above all these natural economic disturbances was the calculated interference from above owing to the fluctuating policy of those who desired to control the tin industry of the world and did not know how to do it. Never perhaps has the widespread ignorance of the world's tin industry been more painfully displayed than in alternations of policy at first hesitating and then economically savage with which this unhappy industry was chastised. To write any concerted history of the year is impossible. So drastically was the censorship applied in Europe that not only was it sought to prevent the publication of prices ruling abroad, but the control of cables and mails rendered it impossible until long afterward to learn even at what rates transactions were done. Thus the English market at any rate for a long time was purely nominal, with the result that business was diverted to the Straits, so that Singapore became for a time the nearest approach to the world's market. This led inevitably under war conditions to the Eastern market freeing itself from the control which had suspended all dealing in London, with the result that about Aug. 13 instructions were sent to the Colony that all dealing was in future to be conducted by a single house, Messrs. Boustead & Co., so that all competitive buying was stopped. It was only a small step further to telegraph daily or from time to time from London the price at which they were authorized to buy, and the price of tin was lowered £2 a ton.

The reasons which led to the extraordinary interference with trade are part of the secret history of the war, probably even of that part the key to which has been lost forever, and engrossing as the study may be, can have little place in a record which seeks to follow certain permanent lines of investigation and keep to ascertained fact and comparative statistics. For this reason, though the year will be memorable to the tin miner throughout the world, the material which presents itself for review is relatively small.

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One remark in the way of criticism may perhaps be ventured without intruding far into the realm of speculation, and that is that the means selected appeared singularly unsuitable to those familiar with the tin industry at the time when they were adopted, and subsequent disclosures as to their effect have greatly strengthened that impression. The tin industry is not a highly organized one permitting of decisions taken at headquarters being rapidly transmitted among producers generally. It is spread all over the world and producers in one country have no means of consultation and joint action, and in many cases have little option but to carry on as best they can. Under these circumstances there was no reason to suppose that there would be any decline in output, especially with the high prices ruling. On the other hand tin-consuming industries generally were greatly contracted by the interference with markets, restrictions on labor and later on the deliberate hampering of "non-essential industries." The panic that developed, therefore, in quarters which had assumed control of the tin industry, was due largely to want of intimate acquaintance with the subject. Reasonable suggestions were disregarded, with the result that the whole industry was thrown out of gear and all kinds of extraordinary expedients are now being tried with a view of enabling the position in various countries to return to a normal state.

The effect upon the tin industry will naturally be wholly bad. Consumption has been interrupted, consumers have been urged to look to tin substitutes, and this disposition has been much encouraged by the grave uncertainty imparted as to future prices and supplies. Particularly, of course, is this the case in the United States, which, during the war at any rate, became responsible for more than half the world's consumption. Here the Tin Control found itself at the armistice with stocks of something over 10,000 tons, which it decided it must sell at the purchased price of some 72 cts. per lb. before permitting any more tin to be imported into the country. As consumers apparently had in addition large stocks, they naturally bought as little as possible when they found the price outside the United States falling rapidly, so that they had to face the prospect that as soon as the control was lifted they could obtain metal at least 20 cts. per lb. cheaper. Such is the position at the time of writing, and the effect upon consumption has been very serious.

Production

In support of the conclusion indicated above that 1918 was not a really satisfactory year for tin miners, some reference may be made to the world's statistics of output. It is always difficult at an early period in the ensuing 12 months to present comprehensive figures of a satisfactory character.

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In the present instance it is quite impossible to do so. Not only so, but estimates must in many cases vary much more widely and be liable to much greater corrections than is usual. Speaking generally, however, no important producer shows any indications of substantial improvement, while many suffered during the year and others, even if improving somewhat on 1917, are still far below pre-war figures. This record to be appreciated must include the consideration that with the great drop in prices witnessed since the armistice tin mines in many cases are now in grave difficulties, as the cost of production rose greatly during last year and cannot be brought down to anything like the extent or with the same rapidity as the fall in the market.

WORLD'S PRODUCTION OF TIN
(In tons of 2240 lb.)

	1914.	1915.	1916.	1917.	1918.
Malaya	49,042	46,766	43,870	39,833(a)	37,370
Bolivia	22,356	21,794	21,145(b)	27,858	27,678
Banka	13,973	13,773	14,548	13,246	12,378
Siam	6,800	7,800(a)	7,800	8,765(c)	9,153
Cornwall	5,056	4,968	4,697	3,936	4,000(a)
Billiton, etc	4,000(a)	5,750	5,000(d)	5,500(a)	4,500(a)
Nigeria	4,517	4,555	5,075	6,510	6,000(a)
China	1,824(b)	3,012(b)	3,800(a)	11,053(b)	11,000(a)
Portugal and Spain	.....	.....	250(a)	750(a)	250(a)
Australia	1,544(b)	2,312(b)	5,000(a)	4,000(a)	4,313(a)
South Africa	2,094	2,089	2,003	1,632	1,235
India	300(a)	500(a)	900(a)	1,200(a)	1,000(a)
Total	111,506	113,319	114,108	124,283	118,877

(a) Estimated. (b) Shipments to Europe and United States. (c) Official, 1917–18. (d) Crude metal exports.

MONTHLY AVERAGE PRICES OF TIN IN 1916, 1917 AND 1918

Month.	New York.			London.		
	1916.	1917.	1918. (a)	1916.	1917.	1918.
January	41.825	44.175	84.00	175.16.4	186.6 .4	293.6 .1
February	42.717	51.420	85.00	181.3 .4	198.19.3	311.12.3
March	50.741	54.388	87.00	193.13.11	207.10.8	318.15.0
April	51.230	55.910	90.00	199.10.0	220.3 .10	329.18.1
May	49.125	63.173	105.00	196.11.9	245.2 .10	364.7 .8
June	42.231	62.053	97.00	179.11.3	242.7 .7	321.10.0
July	38.510	62.570	98.00	168.9 .6	242.6 .6	359.17.9
August	38.565	62.681	90.00	169.19.9	243.18.8	380.16.8
September	38.830	61.542	80.00	171.8 .4	243.19.4	343.19.1
October	41.241	61.851	80.00	179.8 .2	247.9 .4	335.10.0
November	44.109	74.740	74.00	186.19.8	275.2 .10	317.7 .7
December	42.635	87.120	71.50	183.9 .1	298.10.3	267.14.3
Average year	43.480	61.802	86.80	182.3 .5	237.13.1	329.11.2

New York in cents per pound; London in pounds, shillings and pence per long ton. (a) Approximate only.

Output of Tin by Countries

Malaya.—The lead possessed by Malaya over other tin-producing portions of the world was further reduced last year. This is in harmony

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with expectations expressed by the writer in earlier volumes of THE MINERAL INDUSTRY. The export, particulars of which were not available until recently, was as follows:

	Long Tons.		Long Tons.		Long Tons.
January	3,149	May	3,332	September	3,166
February	3,191	June	2,950	October	2,870
March	2,608	July	3,373	November	3,131
April	3,308	August	3,259	December	3,023
Total					37,370

The total of 37,370 tons compares with 39,833 tons in 1917, thus showing a decline of 2463 tons. It is now practically admitted that a further decline in the ensuing year is certain, and a Commission is now sitting to investigate the position and prospects of the industry. Under these circumstances the Senior Warden of Mines, Mr. Eyre Kenney, Chief Official of the Mines Department, in his report on the industry for last year, excuses himself from offering any observations on the subject, with the exception of the following, which is perhaps indicative of the way feeling is shaping: "It has been clearly indicated that the tin deposits of these States are by no means inexhaustible and the conservation of the tin resources is worthy of careful consideration, not only with regard to local requirements, but also in reference to the Empire's position in the tin trade." The subject was much more definitely dealt with by the President of the F. M. S. Chamber of Mines in his Presidential address reviewing the year, delivered last March. After pointing out that production showed a decrease of 6 per cent. from 1917 he stated: "It is my opinion that the Government of this country must face a further gradual decrease in the output for the next 5 years. Anyone who has carefully studied the statistics relative to the tin industry will agree with me that we are now passing through the transitional stage usual in the history of all mining fields. We have drawn heavily on the richer deposits and have worked them under most advantageous conditions, and we are now faced with the exploitation of ground of lower grade which can only be worked economically and profitably with up-to-date machinery. Smaller mines will, I think, find it increasingly difficult to produce at a profit and will probably in time cease to exist. As an industry we must set ourselves the task of trying every expedient to reduce our cost of production if we are to compete successfully in the world's markets, and instead of speculating on a probable rise in the price of tin we ought to confine ourselves to making a reduction in our cost of production."

Passing now from individual opinion to statistics, a noticeable fact is the heavy decline in the output of the chief producer, Perak. Selangor and Negri Sembilan have had their period of marked decadence earlier,

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but Perak had held out fairly well against the prevailing tendency. Actual percentages of decrease are: Perak, 6.47; Selangor, 2.74; Negri Sembilan, 6.84; Pahang, 13.79 per cent. These declines occurred in a year of absolutely record prices. The average throughout the year was $150.62 per picul; the highest price reached was $182.50 on Aug. 4, and the lowest $117.50 per picul on Jan. 4, giving a spread of $65 per picul. The mining industry, of course, did not get the full value of the advance. The average Straits price was £295 4s. 4d. per ton, as compared with £329 11s. 2d. in London, thus showing a difference of £ 34 6s. 10d. This was accounted for mainly by the enormously enhanced cost of freight and insurance, but besides that smelters charges increased and stood at $4.63 per picul of ore, compared with $2.60 per picul in 1913, an advance of about 80 per cent. Further, the duty, which is on a sliding scale, operated against the miner, amounting last year to $18.45 per picul of tin. The average ore price throughout the year was $108.50. At the same time a discrepancy between the London and Singapore price existed after the appointment of Messrs. Boustead as sole buying agents, which has never been satisfactorily explained and which caused much unfavorable comment not only by the miners but even by the Straits Trading Co. This is shown by the following figures giving the average price in London and Singapore during August, September, October and November of last year:

	London c.i.f.		Singapore.		Spread.			Freight, etc.			Difference.		
	£.	s.	£.	s.	£.	s.	d.	£.	s.	d.	£.	s.	d.
August	384	..	337	5	46	15	..	34	..	..	12	15	..
September	345	..	299	13	45	6	2	31	3	2	14	3	..
October	337	..	297	..	40	..	..	31	..	..	9	..	..
November	311	12	275	16	35	16	..	18	6	2	17	9	10

As showing the extraordinary extent of the charges to which tin was subjected after smelting, it is interesting to note that the cost of delivery of tin from the Straits Trading Co.'s works to London warehouse before the war was $1.25 per picul, whereas in September, 1918, the charge was $15.50 per picul.

A further unfavorable feature is that though the output fell off the labor force increased considerably. The number of men employed rose to 144,621, an increase in numbers of 21,281 on the total of 123,340 employed in 1917. These statistics appear to have been somewhat of a surprise, as it was widely stated that the decline in output was due partly to miners having gone North to Siam and the Protected States, whereas it appears that the F. M. S. mines had a considerably larger complement and that in spite of the fact that there was an excess of

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departures over arrivals among the Chinese population. Tin mining in the East is so largely still a matter of manual labor that the supply of coolies is the first consideration in estimating fluctuations of output. The labor situation at the present time presents certain obvious features of future difficulty. The coolie labor is derived from southern China and comes to Malaya in order to earn money which is sent back home to China, to which the emigrant always hopes to return. Owing to the immense rise in silver such remittances are now deprived of practically half their value and should the rise prove to be permanent, as is generally expected, the Chinese coolie will want a much larger wage in the gold standard currency of Malaya than before. The difficulty is slightly alluded to in the Government report as follows: "Conditions under which mining labor now comes from China have changed and in future an organization for facilitating emigration will be necessary."

Any notice of the year 1918 in Malaya would be incomplete without some reference to the difficulties which ensued after the armistice. It has already been mentioned that the British Government restricted buying to a single agency at a price directed from London from Aug. 4. Early in September in answer to protests against the systematic price reduction the price was fixed as from Sept. 13 at $149.78 per picul. After Christmas buying ceased altogether, and about this time an offer appears to have been made by the Straits Trading Co. to purchase at $90. This drop in price caused general consternation and representations were made to the F. M. S. Government that it would be impossible for many Chinese firms to settle their year's accounts as is their custom at the Chinese New Year unless some assistance was given. As a result of negotiations the Government undertook to buy tin offered up to the New Year at $118. Subsequently, purchases were made at $100 per picul, but the Government was naturally loath to undertake an unlimited liability, and how the position developed subsequently is unknown at the time of writing, beyond the fact that the F. M. S. Government holds 6000 tons of tin, the sale of which it is trying to negotiate.

Owing to the conditions under which the Government report has been prepared no reference is made to the operations of the individual mines. Generally speaking it is believed that the prosperous European-owned mines, which are well equipped with mechanical plant and usually sell on long-term contracts, have not felt the pinch in the same way as the Chinese mines, which have to pay wages and keep many thousands of coolies. At the same time they have undoubtedly been affected by the operation of the Excess Profits Tax and the difficulties of obtaining supplies and spares. Fourteen bucket dredges worked in Perak, one in Selangor and one in Pahang, while two more were under construction. The

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following table shows the production of the F. M. S. by states during recent years:

PRODUCTION OF TIN BY STATES (a)
(In piculs of 133⅓ lb.)

	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Perak.....	461,665	421,335	437,339	477,240	493,753	479,621	466,634	457,660	414,000	386,126
Selangor.....	266,007	240,192	231,175	255,382	252,765	244,665	234,155	205,650	184,135	180,505
Negri Sembilan.	48,072	34,697	29,230	29,071	36,821	35,900	20,900	15,240	12,328	10,505
Pahang.....	43,144	40,674	43,954	51,779	58,791	63,723	63,980	54,464	58,734	50,679
Total.....	818,888	736,898	741,698	813,472	842,130	823,909	785,670	737,014	669,197	627,815

(a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. Government.

United States.—As was to be expected under the intense demand for production of every kind in the United States during the war, there was little leisure left for the pursuit of tin deposits. In Alaska the output fell off again considerably and amounted only to 68 short tons of tin. Most of this came from the Buck Creek dredge in the York district. Stream tin was also obtained by sluicing at one mine in the York District and from several others in the Hot Springs district. The investigation of the Lost River lodes was continued, but nothing won. Discoveries of stream tin are reported from Yontna River, Boob Creek, Willow Creek, Riglagalik River, and in the Seward Peninsula from the Potato and Humboldt Creeks as well as from Moran Creek, where 2½ lb. of tin and 10 cts. gold to the cubic yard are reported.

There was some talk during the year of operating the deposits at Irish Creek, Rockbridge County, Virginia. These were worked between 1883 and 1893. Latterly, however, nothing more has been heard of the project and with the general disorganization of the tin industry at the present time the reopening of old ground cannot have the same inducements as during the pressure of war and the fear of scarcity. Another concern in which interest is apparently still maintained is the property of the American Tin Mining Co., originally owned by the Harney Peak Co., near Hill City, South Dakota.

This company was formerly the American Tin & Tungsten Mining Co. and does not appear to be entirely a tin-mining venture. In any case there does not appear to have been any production during the year except from Alaska.

IMPORTS OF TIN INTO THE UNITED STATES

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1906..	101,027,188	$37,446,508	1911.	106,936,872	$43,390,639	1916.	149,237,760	$55,840,205
1907..	82,548,838	32,075,091	1912.	116,003,385	50,371,102	1917.	154,470,040	68,372,034
1908..	82,503,190	23,932,560	1913.	104,282,230	46,900,314	1918.	164,579,905	104,588,619
1909..	95,350,020	27,559,937	1914.	95,049,612	32,861,188			
1910..	105,137,740	33,921,449	1915.	115,636,332	38,736,909			

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Mexico.—During the year tin was worked on a small scale in Mexico in view of the cutting off of all foreign supplies. Some of the small deposits of stream tin near El Cubo, Guanajuato, were worked to supply local requirements for babbitt and solder. Nothing of a permanent character, however, seems to be developed nor is there any production of statistical importance.

Great Britain.—The tin industry in Great Britain passed through a difficult time last year, which has been followed by an outlook which with a continuance of present prices can only spell disaster for old-fashioned concerns. Despite the great price to which tin advanced the mine complements were so heavily drawn upon for recruiting purposes that absolutely no development was possible, and had it not been for the increasing output of new mines the production would have shown distinct decline. From such data as are at present available, the writer calculates that the output of metal will be as nearly as possible 4000 tons, compared with 3936 tons in 1917. From figures prepared by the Cornish Chamber of Mines the output of the chief producers is as follows:

	Long Tons.	
	1918.	1917.
East Pool	1,280	934
Dolcoath	827	968
South Crofty	581	695
Grenville United	451	455
Geevor	418	299
Tincroft	379	458
Basset	318	457
Tresavean	311	240
Levant	278	372
Giew	180	145

Since the fall in tin, Basset has definitely closed down, and with the exception of East Pool and perhaps South Crofty none of the larger central mines about Carn Brea Hill can be making a profit. Newer ventures like Geevor, Giew and Tresavean in other districts claim to be able to progress, but these are really developing mines and it is impossible to judge how far they will be able to maintain the industry without knowing more of what reserves they have opened up for a substantial crushing capacity. The older mines have simply been unable to do any development in view of the necessity of maintaining output to meet costs. Consequently, as their miners return they cannot develop their output because they have no developed ground waiting to be stoped. Earnest representations have been made to the Government for assistance to tide over the present difficult period, but thus far there is no indication of any assistance being forthcoming and the handling of the situation in Cornwall during the war

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does not indicate an appreciation of the situation which would justify hopes of such intervention. The seriousness of the situation is further indicated by the action of the leaders of the miners, who admitted before the arbitration referees that many of the mines could not stand higher wages, inadequate as these were. For many of the mines the situation is rendered still more acute through the very heavy fall in the price of arsenic and the temporary unmarketability of wolfram. Cornish mines in many cases have very heavy water to meet and the most serious item is the increased charge of fuel, amounting to something like £175,000 per year in 1918, a charge which is likely to be materially increased this year.

South Africa.—Tin mining in South Africa has, of course, felt the stress of war and the enhancement of cost. The output of black tin was 2106 short tons, compared with 2858 short tons in the previous year, representing about 1235 tons of metal compared with 1632 tons in 1917. Tin mining in South Africa has been disorganized by the interruption in shipping. Ordinarily the South African concentrates have been sent to the Straits for reduction. Last year, however, it became impossible to secure freight, so to supply local requirements of metal the Union Government offered a highly satisfactory price to local companies to undertake the smelting of their own ores. Details of the contracts arranged are not available, but the Zaaiplaats Tin Co. produced 71 tons of 99.7-per cent. tin in the quarter ending Jan. 31, 1919, and 328 tons in the previous year. At this rate their output would be about 300 tons of metal a year. The Lieuwpoort Tin Mines have also like the Zaaiplaats erected a reverberatory furnace. Their ores, however, are far less clean than those of the Zaaiplaats company and the production of high-grade metal will be for them a more difficult proposition. The Swazi Tin Co. is also reported recently to be constructing a small furnace. Ordinarily speaking the consumption of tin in South Africa is calculated at about 300 tons per annum, so it is obvious that if the temporary expedient of local smelting is continued some of the tin will have to be sold abroad. Everything depends on whether the Union Government will continue to grant terms to encourage local smelting, as under normal circumstances it cannot be done in competition with the big smelters in the East. For the moment there is probably some accumulation of ore in South Africa awaiting treatment.

No particulars are at present available indicating any fresh discoveries in the country.

Bolivia.—Bolivia was the only big producer in a position to profit fully by the remarkable prices of 1918. None the less the output did not show the increase commonly anticipated, and this was due no doubt to the fact that the mines have been fully employed in previous years and it was

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impossible to obtain any more power plant and mechanical appliances. The output is reported as 27,678 metric tons as compared with 27,858 tons in the previous year. It is observable that the Bolivian output in the last two years has advanced considerably, while that of the Malay States is going back, and the time is probably not far distant when Bolivia will become the largest producer in the world. Her output is derived entirely from lodes, and as the alluvial deposits of the Malay States are obviously becoming exhausted the future lies with the country with the primary deposits. In addition to that the grade of the Bolivian mines is, of course, far richer than anything elsewhere and if capital in Europe or America were to have opportunities of acquiring good properties there, the possibilities of enlarged production are great and limited mainly by the restricted amount of labor available. Definite data of the industry last year beyond the figures of output given above are not available to the writer. The Llallagua Co. made a gross profit for 1917 of £1,712,170, and presumably did even better last year. These mines are the largest producers in the world and toward the end of the year were said to be producing at the rate of 1800 tons of concentrates per month. Sr. Patiño's Uncia mines are credited with 1000 tons of concentrates per month and when his Huanuni property is re-equipped his output will show further increase. The Aramayo Francke mines have continued a steady output, the output for 1918 amounting to 1845 tons. Arrangements have recently been completed for the flotation of a company in London to take over Messrs. Penny and Duncan's mines at Morococala and Tres Cruces. In addition the Berenguela company has acquired a second property and should also enhance its output.

Considerable obscurity veils the smelting enterprises conceived for local smelting. About 374 tons of bar tin was exported in 1917 and 262 tons in the first half of last year. Shipments since that date have continued to include small parcels. These consignments are presumably from the little smelters in Potosi. The experimental electric furnace started at La Paz was entirely unsuccessful. A high-grade tin was reported, but the slag contained as high as 15 per cent. and could not be re-smelted. The chief feature of the year was the activity of the Llallagua Tin Mining Co. in developing a smelting company at Arica. The capacity of this furnace is stated to have been designed for an output of 12,000 tons of metal per year, but thus far evidence of its activity is wanting. Probably the company found it preferable to send their ores to the United States, where at one time a margin of £60 or £70 over London prices developed, and though an embargo was subsequently placed on the import of concentrates it yet remains to be seen whether the policy much advocated in the United States of maintaining higher prices for tin so as to attract

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the Bolivian ores to the American smelters rather than to England will be to any extent adopted.

Exports of tin ore from Bolivia in recent years are as follows:

EXPORTATION OF TIN ORE FROM BOLIVIA
(In metric tons)

Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)
1901..	21,573	12,943	1907.	27,678	16,607	1913...	44,594	26,756
1902..	17,340	10,404	1908.	29,938	17,963	1914...	37,259	22,355
1903..	21,785	13,071	1909.	35,566	21,340	1915...	36,324	21,794
1904..	20,369	12,221	1910.	38,548	23,129	1916...	35,097	21,145
1905..	27,690	16,614	1911.	37,073	22,434	1917...	46,420	27,858
1906..	29,370	17,624	1912.	38,378	23,027	1918...	.....	27,678

(a) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

China.—The writer is unfortunately not in a position to command any reliable statistics of tin production in China during 1918. Outside the Kokiu mines in the Mengtsz district of Yunnan production is negligible. Within that district it is believed that the production could be largely increased did the supply of water permit. At the present moment, however, the output is governed by the supply of water available and it is not likely that last year's production of tin can have much exceeded if it reached that of 1917. On the other hand exports may have been larger, as there was a large accumulation of ore unwashed. Commercial estimates given the writer place exports at about 11,000 tons at the mines in 1917, owing to the drought. Conditions under which the industry is carried on about Mengtsz are subject to many vicissitudes. Smelting costs have advanced enormously, owing particularly to the price of fuel, while the advance in price and scarcity of silver has done much more to render the possibility of cheap production of tin to be sold to countries using the gold standard out of the question. During 1918 the restrictions on sales and exports from the Straits drove trade to Hong Kong and China, where purchases for Japanese and American account ran prices up to record heights, and it was reported at one time that tin had been bought as high as £530 per ton. Subsequently, however, Hong Kong exports were controlled, with the result that increasing stocks accumulated, amounting in May of the current year to probably at least 3000 tons. This accumulation was facilitated by the fact that the tin was produced in Yunnan at a cost which did not permit of its realization under a gold currency without heavy loss. Details furnished in the Chinese Maritime Customs report on trade in Yunnan indicate the volcanic conditions under which the tin industry has operated there during the last few years. Accurate information as to exact conditions in the Kokiu mines in the Mengtsz district are always difficult to obtain

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and in consequence opinions of their richness and potential output vary widely. The Chinese Guild or Corporation, which controls the working of the mines, of the native smelters and of the transport of the ore, and which is said to be closely related to the refineries in Hong Kong, has been, in past years at any rate, unfriendly to outside investigation and very jealous of any attempt by Europeans to secure a footing in the industry. While many exaggerated estimates of output have appeared from time to time, there can be no question that as the price of tin has advanced the output has shown a progressive though not a regular increase. Thus in 1890 exports amounted to 22,121 piculs and in 1917, the last year for which statistics are available, they had risen to 185,634 piculs or 11,053 tons of crude metal. When this tin, which has on occasion been reported to average about 90 per cent. metal, has been refined at Hong Kong, the eventual yield would probably be about 10,000 tons. It is, of course, impossible to obtain statistics of production, and there are frequently accumulations of metal from one year which are disposed of later when the market is favorable, as occurred during 1917, which began with a disposal of large stocks accumulated during the previous year. As is often the case with an industry which has been in existence for a very long period, prescription plays an important part in the economic position of the field. The Kokiu Guild has from immemorial times refused to permit the export of ore. As the town and district depend largely on the profits derived for the mining, smelting and transport of tin with their attendant squeezes, it looked naturally with hostility upon attempts made by the Anglo-French China Corp. and by the Straits Trading Co. during the year to enter the field as ore buyers and these firms found themselves quite unable to carry through their projects. As things stand, therefore, the Guild remained masters of the situation, but the Straits Trading Co.'s attempt is interesting confirmation of the opinion hazarded in MINERAL INDUSTRY, **25**, that the company in extending its great smelter might find it difficult to maintain a full supply of ore. Somewhat naturally, however, the prospects of enlarging the output were alluring, as it is maintained that production is artificially limited by the conditions under which the Guild permits the industry to be carried on. In practice today the output is limited by the supply of water in the neighborhood of Kokiu for the purposes of dressing the ore. The wet season begins about May and it is the practice from the New Year onward to force the output so as to have a large accumulation of material to wash when the rains come. Several schemes have been suggested to improve output. One of these is for the Guild to permit the export of concentrate in excess of the reduction of the smelters, while a second and possibly complementary suggestion is for the transport of ore to Tatung Lake in order to

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increase the supply which can be concentrated, as it is, of course, out of the question to transport the crude ore. It does not, however, seem that these projects were accepted and under the now existing conditions in the tin industry there can be little temptation to press them.

Belgian Congo.—There was apparently a continuance of the previous small output from the Belgian Congo last year; as far as the writer was able to learn about 150 tons of high-grade concentrates running up to 75 per cent. SnO_2 was received by smelters in the United Kingdom and one or two small parcels have been delivered this year.

Deposits.[1]—The known tin deposits in the Belgian Congo consist of cassiterite lodes and of stream tin, the latter being eluvial—in the vicinity of the lodes—and alluvial. As in other parts of Africa, the primary deposits are pegmatite veins, subsequently pneumatolysed; but none of them is sufficiently rich in tin to be profitably worked in view of the high cost of production and the difficulties of transport. Reports of 5 per cent. of cassiterite and more have for the most part been merely launched for speculative purposes.

More important and promising are the eluvial deposits of stream tin from these lodes, some of which are sufficiently extensive and high in tin to have already been the subject of tentative working. The largest are situated in Middle Katanga, where they occupy a zone extending from the Niemba (a tributary of the Lukuga) on the northeast to the Bia Hills, bordering the Lualaba Valley on the southwest, the most important being at Muika—to the south of Kiambi, on the Luvua—and in the Bia Hills.

The Muika deposits are about 15 km. south of the government post at Kiambi, and lie for the most part on the eastern bank of the Luvua. The region consists chiefly of dark quartzites and micaceous schists, as well as gneiss, more or less steeply tilted and folded, and running in the general direction N.N.E., S.S.W. Frequent interruptions of intrusive rock cause appreciable changes in the line of strike. The lodes are mainly pegmatite (more rarely granite), partly following the strike, but sometimes occurring in fissures. The lodes are mostly lenticular, seldom exceeding 50 to 80 meters in length, and varying in thickness from 3 to 10 meters. One of them, however, is about 900 meters long, with an average thickness of 4 to 5 meters.

In general, Muika ore is low grade, averaging—according to the engineer in charge—0.2 to 0.5 per cent., and only attaining 1 per cent. in selected specimens. In some cases the lodes contain more tin at one end than the other, and the marginal zones are richer than the interior of the lenticular mass of pegmatite.

[1] F. Behrend, *Min. Jour.*, July 5, 1919.

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Owing to the small amount of ore, no systematic working of the lodes has been attempted, but greater hopes are entertained of the eluvial and alluvial deposits. These are frequently covered with up to 1½ meters of weathered detritus containing fragments of various sizes carrying cassiterite. Systematic prospecting, however, has shown that even here there is no great concentration, and that the tin is very irregularly distributed. The portions regarded as workable contain 0.06 to 0.07 per cent., as compared with 0.1 to 0.15 per cent. in the Malayan deposits.

During the war these stream tin deposits have been worked, and have probably been concentrated by the aid of water pumped up from the Luvua.

Bia Hills.—This region contains the most extensive tin deposits in the Belgian Congo. They are situated between lat. 8° and 10° S., in the angle between the Lualaba and Lufira and south of Lake Upemba. A number of granite ridges—forming the Bia Hills and their northern and southern extensions—have intruded in a massif of steeply pitched crystalline schists, and run parallel with the stratification in a N.E.-S.W. direction. The granite itself, and still more the adjacent sedimentary deposits, are intersected with more recent pegmatite lodes, partially modified into greisen. These lodes for the most part traverse the country rock at right angles, and are reported to carry a uniform percentage of tin, though there are no data available as to the exact amount. There is also another, smaller, series of lodes at right angles to the first, but with a very irregular content of tin. The greisen consist principally of quartz and potash mica.

At the outcrop of these tin lodes, some of which can be traced for 1400 meters, eluvial deposits have been formed with a mean thickness of 60 cm. and a reported average content of 1 per cent. of tin ore. The richest are at Busanga, where they cover an area of over 100 hectares and are considered to contain 120 to 150 tons of tin oxide. Other rich deposits are at Kassonso and Shikoli. Many of the prospecting claims filed in this region, however, are alluvials derived from the rivers draining or intersecting the granite, and mainly along the eastern bank of the Lualaba. The deposits extend nearly to the junction with the Luvua. Their content is unknown, but will certainly be low and irregular, so that most of them will not be worth working. The Belgians estimate that the district contains about 20,000 tons of tin, but there is no definite information to check this assumption, no systematic working having been undertaken.

Kibara Hills.—Fairly extensive deposits of stream tin occur along the Lukussi river, which enters the lower reaches of the Luvua from the south, and also on the northeastern shore of Lake Kamba, but these

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appear to be alluvial in origin, and, therefore, of irregular quality. Those on Lake Kabamba have been derived from small, low-grade lodes in the Mumbue Hills (Luabala valley), and are reported to carry 0.05 per cent. of ore to the ton. This estimate, however, is probably high, and the cost of working would probably be considerable.

Niemba River.—Between the confluence of the Niemba and the Lukuga and Lake Tanganyika, a few pegmatite lodes and stream tin deposits of unknown content have been proved. Other deposits of similar character are known in the district east of Kabambare on the Luama, in the vicinity of the Zobia post on the Bima, and in several adjacent places, but no details are available.

The Katanga deposits are, in general, favorably situated both for shipment down the Congo via Boma, and to the south via Elisabethville-Cape Town, or Elisabethville-Beira; but in the event of the tin output attaining any considerable dimensions, the most direct and cheapest route to the coast will be over the Belgian Lukuga railway, Lake Tanganyika, and (ex-)German East Africa.

Dutch Indies.—The position of the Dutch tin trade is obscure, and though rumors are plentiful reliable information is wanting. According to reports in London, the production in 1918 was slightly below normal, the monthly figures being as follows:

	Tons.		Tons.		Tons.
January	1,560	May	839	September	1,167
February	2,186	June	854	October	1,116
March	190	July	846	November	880
April	580	August	990	December	1,170
				Total	12,378

This total compares with 12,364 tons in 1917. Exports during 1918 are reported as follows: United States, 7739 tons; Japan, 1624; France, 532; Straits Settlements, 355; sundry, 1316; total, 11,566 tons. This compares with a total export of 15,605 tons in 1917 and 19,640 tons in 1916. The writer has no figures for the Billiton and Singkep companies, but assuming a reduction of 100 tons, there should have been a production of not less than 17,000 tons from the Dutch Islands. Consequently, it is obvious that there must have been considerable accumulation of supplies. These stocks are estimated, probably on the basis of the statistics above quoted, at between 3000 and 4000 tons, and the writer also believes that there are or were recently something like 1000 tons of Banka held in Hong Kong.

The reason for the decreased exports from Batavia in 1918 was the great diminution in American takings. The circumstances causing this decline at a time when the Allies were supposed to be peculiarly short of

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tin are not clearly known. It will be remembered, however, that the United States seized Dutch shipping in their ports, and it was understood at the time that a Government embargo on shipments to America was the reply. So far as can be learned, however, this embargo did not last long, though it is reported that its effect on business continued for a considerable period. Exact circumstances, however, are not known. In August the price rose sharply under the influence of the restrictions on supplies which produced famine prices everywhere, and the Government ultimately fixed its limit at 264.50 florins. During August, however, the price crumbled and at the end of the year the Government limit had been lowered to 150 florins per picul, Hong Kong being the chief purchaser on the fall.

India.—No statistics are available of the production of tin in British India last year. The output of wolfram concentrate from Tavoy was, however, 3600 tons as compared with 3652 tons in 1917. As these concentrates contain a very considerable proportion of tin it is probable that the Indian output was again considerable, possibly as much as 1000 tons of metal. In any case it is impossible to arrive at the figures, as the tin content from the different mines varies. Since the prospects for tungsten mining have been declining a general disposition is noticeable to emphasize the increased tin content of the ores won. In some cases during the tungsten boom the presence of tin was entirely overlooked, and it is probable that in the future we shall hear more of the tin production from Burma, as obviously many of the companies will have to look much more closely after their recoveries than they did during the boom period.

A detailed account of the geology and occurrence of tin in Burma was contributed by M. C. Brown in the *Records of the Geological Survey of India.*[1]

Australia.—Complete figures of the Australian output are not available. Shipments are estimated at approximately 3500 tons. The Tasmanian production was 2637 tons of black tin, a gain of about 400 tons on the year. This would have yielded approximately 1793 tons of metal. Whether this ore was entirely smelted is not known, as the production from the Mount Bischoff smelter was only 1435 tons and the writer does not yet know whether with other smelters shut down, as was the case at the end of the year, the balance of concentrates could have been reduced at other works. In Queensland the output of black tin also increased and amounted to 1311 tons, or say 852 tons of metal, compared with 1177 tons in 1917. How much of this was smelted is also unknown, as there was a considerable accumulation of tin at the end of the year which could not be reduced owing to the closing down of the Irvinebank

[1] *Min. Jour.*, Nov. 23, 1918, p. 683.

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smelter, and the Government undertook to advance to miners to the extent of £100 per ton on concentrates which they could not sell. The New South Wales output amounted to 1433 tons of metal, compared with 1764 tons in 1917. That of Western Australia, calculated from the value given, amounted to 235 tons of metal. Adding these items together we get the following:

	Tons.
Tasmania	1793
New South Wales	1433
Queensland	852
Western Australia	235
Total	4313

Australia apparently managed to avoid the control of prices fixed by the Inter-Allied Tin Control: the *Industrial Australian* in August last mentioned the sale of a parcel of tin at £412 per ton and observed: "We are in a position to state that firms in Melbourne are buying tin for export at prices quite beyond the rates cabled daily from London and America as ruling there. When the facts relating to these purchases come to light they will form interesting reading to all concerned in tin production."

The *Sydney Morning Herald* recently presented some interesting figures of the output of the tin fields of New South Wales.[1]

The value of tin ore produced to the end of 1918 is $56,022,564. The value of the output for the year 1918 was $2,671,105, as compared with $1,818,592 in the preceding year, thus showing an increase of $852,513. In the Emmaville division the output amounted to 873½ tons, valued at $934,928, as compared with 936 tons, valued at $688,941, in the previous year. The yield from the Tingha division was 610½ tons, valued at $739,708, as against 600 tons, valued at $440,676, in 1917. The output from the Wilson's Downfall division totaled 155 tons, valued at $167,602, as compared with 128 tons, valued at $84,502, in the preceding year. The yield from the Glen Innes division amounted to 143¼ tons, valued at $152,336. In the Torrington division the production was estimated at 90 tons, valued at $89,057. The output from the Ardlethan division was valued at $376,584, as compared with $302,059, in 1917.

The tin ore recovered by the dredges during the year amounted to 1253 tons, valued at $1,374,241, which was an increase of $482,913 in value on that produced in 1917. The most successful results were secured by the plants in the Emmaville division, the output of tin recovered amounting to 504 tons, valued at $539,598, as against 520 tons, valued at $383,655, in 1917. In the Tingha division the output totaled 444 tons, valued at $497,950, as compared with 403 tons, valued at $294,589, in 1917. The yield from the Glen Innes division amounted to 123 tons,

[1] *Comm. Rept.*, July 25, 1919.

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valued at $134,812, as against 132 tons, valued at $102,673, in the year 1917. In the Wilson's Downfall division the production was 145 tons, valued at $158,974, as compared with 118 tons, valued at $78,536, in the preceding year. There were 50 plants in operation during the year in winning tin ore.

Nigeria.—The anticipations of an increased output from Nigeria last year did not eventuate, and it seems probable that the production was lower. The Niger Co., which is the only source from which comprehensive data can be obtained, are unwilling this year to supply figures and consequently only the import figures into the United Kingdom are available to the writer as the basis of production. There seems every reason to suppose that these are representative. So far as he can discover all the tin was shipped into the United Kingdom, and reasons developed during the year which made it improbable quite apart from the great price of tin that concentrates were being accumulated at the mines and not shipped. The decline in the output appears to have been due to two causes: (1) The peculiar extent to which the Excess Profits Tax hit most of the Nigerian mines, and (2) the effect of the influenza epidemic in the autumn, which disorganized labor widely. As regards the first influence, the Excess Profits Tax, it must be remembered that all the companies are London concerns, and besides the properties are alluvial, with lives which cannot be very prolonged. In some cases calabashing areas have been worked out and the companies depend upon machinery of one kind or another to maintain production from such leases. The war has, of course, occasioned great delay in the supply of anything of the kind. As regards labor, some disturbance, more particularly to transport, was reported at one time as due to the enlistment of carriers for East Africa, and toward the end of the year a labor unsettlement was reported from the Coast and it is unknown at present how far the world-wide demand for increased labor has penetrated up country.

The following is the monthly total of arrivals of tin in the United Kingdom during the year:

NIGERIAN TIN IMPORTS INTO GREAT BRITAIN, 1918

	Ore, Long Tons.	Metal, Long Tons.
January	849	594
February	540	378
March	719	503
April	1371	960
May	1114	780
June	518	363
July	380	266
August	45	31
September	1182	826
October	32	22
November	1009	706
December	657	460
Total	8416	

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Spanish Peninsula.—The writer has been unable to obtain any figures of output in Spain and Portugal. Owing to the embargo on tin, exports were prohibited for a considerable time and with the enormous prices which tin sometimes commanded in the country, owing to shortage of supply, every effort was made to convert whatever ore was available into metal. For these reasons it may be assumed that production from ordinary sources would be about 250 tons. The writer has no information as to what was produced by the American dredging company operating near Guia on the Spanish border. Any output from this source will be additional to that estimated. With the removal of war restrictions shipments of small parcels from Portugal to the United Kingdom have recently recommenced.

Siam.—The official statistics of output from Siam are not available for European calendar years. That for 1916–1917 was 8765 tons and for 1917–1918, 9153 tons. Beyond these totals little real information is available. The London-owned companies were affected by the operation of the Excess Profits Tax, and consequently the increase was probably due to the stimulation of the Australian-owned dredges, particularly the Tongkah Harbor, the Tongkah Compound, Deebook, Katoo Deebook, Ratruit Basin and Bagoon Valley companies. Many reports of discoveries and of the investment of United States capital on a considerable scale have been reported, but the reports are unverifiable up to the present.

Secondary Tin

Notice of the tin industry would be incomplete without reference to the production of secondary tin. Statistics of this production are carefully compiled for America in the Annual Report of the United States Geological Survey dealing with the Secondary Metals.[1] Figures for last year are, of course, not yet available, but the estimate for 1917 was 19,400 short tons, the production being equal to 25 per cent. of the imports. Of this amount 6000 short tons was returned as metal and 13,400 short tons as alloys and chemical compounds.

The writer is unaware of any similar statistics being available for other countries than the United States. During last year it is possible that the recovery exceeded 25 per cent. of the imports, in view of the national campaign for economy in the use of virgin tin and the very high prices ruling.

Economies in Tin Consumption

One of the questions which some years' experience alone will enable us to answer is what permanent changes or modifications in the use of industrial metals will eventuate from the war. In regard to tin two views are current. There is what may be called the conservative view, which

[1] "Secondary Metals in 1917." J. P. Dunlop, U. S. Geol. Surv., Feb. 19, 1919.

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is that tin has been used along certain leading lines for so many years past independent of fluctuations in price that it may be regarded as practically indispensable. Those who hold this view point also to the fact that fluctuations in the price of the metals such as we have experienced mean only a trifling and generally inappreciable change in the prices of the commodity as finally retailed. Besides, the manufacturer has an article on which he knows he can rely and traders in matters of this kind which involve the credit of their goods are very loath to embark on experiment. While the soundness of these views cannot be questioned there is no doubt that the shortage of tin last year caused a much more serious study of substitutes than had ever been attempted before. Cardboard cartons, containers and boxes were extensively employed for domestic trade and considerable competition must be looked for from this source, at any rate for consignments where long storage or rough handling is not expected. The question, of course, is not one of tin only; it will be affected also by the price of bars and generally the selling price of tinplate. There seems no reason why aluminium foil should not take the place of tin foil in view of the greater output of aluminium and the cheaper price. One reason which makes any opinion on the subject very hazardous is that a period of close competition in selling prices has not yet been reached and consequently the inducement to economize in externals has hardly risen.

Metallurgy

Apart from the study of means of economizing use in tin which formed the subject[1] of a special conference of the American Institute of Mining Engineers at Milwaukee in October, and which was rather a study in the technology of possible competitors of tin, there is exceedingly little to record during the year in question. A number of small smelting plants were set up, more especially as noticed above in South Africa and the Spanish Peninsula; but these were not designed to develop any new process, but intended to supply local demand at exceptional prices. The interesting experiments being tried out with the Richards Volatilization process at East Pool in Cornwall were brought to an abrupt conclusion by the Government commandeering the furnace, and the operations of the Hames Metal Co. closed under the Non-ferrous Metals Industry Act; and though a further report by the Tin and Tungsten Committee of the Scientific Advisory Committee to the Privy Council was promised, its appearance is still delayed, and it seems unlikely that it will be able to report anything of immediate consequence. The writer, in Vol. XXVI of The Mineral Industry, gave reasons for not anticipating results of practical importance from the inquiry as originally initiated, and so far sees no reason to modify that view.

[1] "Symposium on the Conservation of Tin." *Bull. Am. Inst. Min. Eng.*, 144, 1729 (1918); *Trans.*, 60, 162.

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TITANIUM AND ZIRCONIUM

By L. E. Barton

Probably few of the chemical elements have received more attention and developed greater interest during the past few years than have titanium and zirconium. Particularly has investigation been stimulated since the United States entered the war, thus creating a demand for a great variety of new products.

While titanium and zirconium are closely related elements, as indicated by their position in the periodic system, the properties of the elements and their corresponding compounds so differ as to indicate dissimilar fields of application. It is interesting to note how closely application of these elements has followed the lines indicated by their properties. This is shown in the following tabulation:

	Titanium.	Zirconium.
Atomic weight	48.1	90.6
Melting point	1795° C.	1530° C.
Principal oxides	Titanous (Ti_2O_3) Titanic (TiO_2)	ZrO_2
Refractive index	TiO_2, 2.75–2.90	ZrO_2, about 2.25
Melting point	TiO_2, 1700° C.	ZrO_2, 2950° C.
Tetrachloride	$TiCl_4$, liquid; boiling point, 138° C.	$ZrCl_4$, solid; sublimes at 400° C.
Industrial application	Alloys, pigments, colored glazes, leather dyeing, textiles (dyeing and bleaching).	Alloys, refractories, white opaque glass, white opaque enamels.

Titanium

The year 1918 has shown a continued development of the titanium industry, not only by increased volume of production, but by development of plant equipment and processes for making titanium products which are of great potential importance.

Figures for 1918 show a production of 261 short tons of rutile and 444 tons of ilmenite in the United States during 1918, mostly from the Virginian deposits of the American Rutile Co.

Of this amount approximately 160 tons was reduced and subsequently manufactured into titanium tetrachloride to be used by army and navy for making smoke-clouds for concealing and spotting purposes,[1] the remainder supplying the usual demands of the arc-lighting, leather, textiles, ceramic and other industries. The price of rutile during the year ranged from $150 to $250 per ton.

[1] "The Rôle Played by Silicon and Titanium Tetrachloride during the Past War." G. A. Richter, *Trans. Am. Electrochem. Soc.*, **35**; presented at the New York meeting, Apr., 1919.

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Comparatively little ilmenite or titaniferous iron ore was produced in the United States, such ore being as usual mostly imported; however, during the year the mining and milling plant of Buckman & Pritchard, Inc., Pablo Beach, Florida, was practically completed, with equipment for large quantity production of ilmenite, zircon, rutile and monazite. The plant is now producing on an industrial scale.

Ferrotitanium for the deoxidation and purification of steel is manufactured by only two companies in the United States: the Titanium Alloy Manufacturing Co., Niagara Falls, N. Y., and the Metal & Thermit Corp., New York. The latter company manufactures only the aluminium-reduced variety of ferrotitanium; the former manufactures mostly the carbon-reduced or ferro-carbon-titanium. Both varieties of ferrotitanium were in active demand during the year.

The price of ferro-carbon-titanium, which had been held constant at $160 per net ton for several years, was advanced in April, 1918, to $200 per net ton.

It is estimated that 2,400,000 tons of steel was made with ferro-carbon-titanium during the year.

Progress has continued in the development of white titanium pigment products. The plant of the Titanium Alloy Manufacturing Co. erected for the manufacture of titanium pigments, but used during the war to increase the production of titanium alloys, is now being refitted for the production of pigments.

Zirconium

Prior to the war investigation of zirconium and its compounds appears to have been confined almost entirely to Germany and Austria. Since that time other nations have taken an active interest in the element, particularly the United States, where important industrial applications of zirconium have been developed.

The most important application of zirconium at the present time is its use as a refractory material, such application being due to the properties of its oxide. Zirconium oxide or zirconia (ZrO_2) has a melting point of 2900 to 3000° C., a coefficient of expansion of 0.00000084, and a specific gravity of 5.80.

The value of zirconia as a highly refractory material is at once indicated by comparison of its melting point with those of other highly refractory oxides, as shown in the following table:

	Melting Point.
Zirconia	2950° C.
Magnesia	2800° C.
Lime	2570° C.
Alumina	2050° C.
Chromium oxide	1990° C.
Silica	1800° C.

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Relative to zirconia as a refractory Rodd[1] says:

"Zirconia is one of the most refractory oxides known, its fusing point being in the neighborhood of 3000° C. Even when containing about 1.25 per cent. of silica and ferric oxide it does not melt below 2560° C. The thermal conductivity of the pure fused material is very low, and it has a very low coefficient of expansion (8.4×10^{-7}) which compares very favorably with that of carborundum (6.58×10^{-6}) or alundum (7.1×10^{-6}). Such a substance can clearly withstand sudden changes of temperature without fear of fracturing. Chemically, zirconia is extremely inert, being highly resistant to acids, fused alkalies, fused quartz or molten glass. No other material known to the chemist possesses such a combination of desirable refractory properties.

"When we come to consider the materials available for the construction of such articles as crucibles, gas-muffles and all gas-fired furnaces, tubes for electric resistance furnaces, arc-furnaces and the like, the range is found to be very limited. Apart from platinum and tungsten, suitable only for small crucibles, etc., and porcelain, the use of which is limited by the softening temperature of the glaze, we have fire-clay, various graphite-clay mixtures, fused silica, magnesite, alundum, graphite, compressed carbon, carborundum, and very few other materials. All these have serious limitations from which zirconia does not suffer. Zirconia is more infusible than the best of them, is not affected by an oxidizing atmosphere as are graphite and carbon, is not attacked by alkalies as is fused silica, nor by acids, as are magnesite and alundum, and is resistant to fluxing, although, of course, at very high temperatures it is readily fluxed by an oxide like magnesia. There is no question that zirconia crucibles, for example, would be superior for many purposes to any of those now obtainable, and on account of its low thermal conductivity it would contribute greatly to the efficiency of furnaces of all types if used as a lining."

Zirconium Ore Supply

Zirconium occurs naturally in only two commercially available forms:

(1) Zirconium oxide in combination with silica as the mineral zircon or zirconium silicate.

(2) Zirconium oxide in the free state, but associated with zircon, silica, iron and other oxides, as in the mineral baddeleyite.

Zircon occurs in North Carolina and Florida in the United States, and in Norway and Brazil. There was no important production of zircon during the year 1918, though the plant of Buckman & Pritchard, Inc., has been practically completed and is now producing a high-grade

[1] "Zirconia as a Refractory," E. H. Rodd, *Jour. Soc. Chem. Ind.*, 37, June 15, 1918.

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concentrate from the deposit[1] at Pablo Beach, Florida, where the zircon occurs as sand associated with other minerals, such as ilmenite, rutile, and monazite.

The only important known deposit of free zirconium oxide or zirconia occurs in Brazil. This deposit, formerly worked by the Germans, is now being worked by the Foote Mineral Co., Philadelphia, who supply zirconia in form of ore, brick, and cement for refractory and other purposes.

The Brazilian ores range from 72 to 95 per cent. zirconium oxide, the average being about 78 per cent. During 1918, the amount of zirconium ore imported was 1400 gross tons, and was quoted at $100 to $140 per ton, depending upon grade or content of zirconium oxide.

Uses

Zirconia in Enameling Industries.—It has long been known that zirconia can be substituted for tin oxide as an opacifying agent for white opaque glass and enamels. Though several patents relative to the subject have been taken out recently in this and other countries, the use of zirconia and zirconium oxide-bearing substances for enameling purposes was practiced as early as 1906 in Germany.[2] Apparently because a sufficiently pure grade of the oxide has not heretofore been available at a reasonable price, the use of zirconia for enameling purposes has not made any considerable progress. Recently methods have been developed in the United States for manufacturing better grades of zirconium oxide with which white opaque enamel-ware of excellent appearance has been made.

Metallic Zirconium and Zirconium Alloys.—Metallic zirconium in crystalline form as a coherent solid has a silver-gray color similar to white cast iron. It has a melting point of approximately 1500° C., and a specific gravity of 6.40. Combined with other metals as alloys it has found useful applications.

Ferro-zirconium produced by reduction with powdered aluminium is said to have been successfully employed in Germany for the production of zirconium steels for armor plate and projectiles.

During the war the Government investigated various steel-hardening elements, including zirconium, with reference to their use in the production of armor plate for tanks, airplanes and other equipment. While progress has been made, it appears that industrial success of such application depends upon further investigation.

[1] For a brief description of the deposit and products obtained at Pablo Beach see MINERAL INDUSTRY, 26, 694 (1917).
[2] German Patent No. 189364, Nov. 21, 1906.

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U. S. Patent No. 1151160 refers to ferro-zirconium containing zirconium 65 per cent., iron 26, titanium 0.12 and aluminium 7.7 per cent. The alloy is malleable and adapted to drawing into wire.

Ferro-zirconium has found limited application as a scavenger for steel.

A new alloy of zirconium and nickel, called cooperite, has been patented in the United States. The alloy is stated to be extremely hard and well adapted for making cutting tools.

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TUNGSTEN

By Colin G. Fink

In the American tungsten industry the year 1918 was an unusual one. The spirit of unrest and feeling of uncertainty prevailed throughout the year, even though prices remained fairly stable. Many of the smaller mines shut down and the high record of production of about 6000 short tons per annum that had been attained during 1916 and 1917 could not be maintained, and the total output for the United States dropped in 1918 to 5041 tons (60 per cent. WO_3 basis).[1] There were a number of contributing causes for this depression: In the early part of the year transportation facilities were very poor and it was often impossible to make shipments from some of the centers. In the spring, an entirely new problem developed. The war had greatly stimulated production of tungsten throughout the world. It had also brought about an intensive search for new localities. The most important of these are the very extensive tungsten districts in Kwantung and Kwangsi Provinces, China. In 1915 China's tungsten production was practically nil. In 1918 it was 9000 metric tons, of which over half was shipped to the United States. In other words, China exported more tungsten to the United States than this whole country produced. Much anxiety was felt among all of the American producers. Influential members of the industry suggested to Congress the passage of a bill providing an import duty on tungsten and all its products. With Chinese ore selling here at $6 to $8 per unit it is impossible for the American miners to compete, particularly if the separation of tin from tungsten is further developed and cheapened.[2] During the summer the United States Tariff Commission held a meeting at Denver to which the Colorado producers were invited and the tungsten situation was discussed at great length. A second tariff meeting was held in San Francisco and a third, during November, in New York. No definite decisions were arrived at. With the signing of the armistice a large accumulation of stocks of concentrates and ferrotungsten followed. In England, too, these stocks continued to increase throughout the close of the year, England having agreed to buy all colonial tungsten at a fixed price for 6 months after signing of peace. There soon was a lack of ware-

[1] F. L. Hess, U. S. Geol. Surv.
[2] Chinese ore contains usually appreciable percentages of tin.

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houses and England was obliged to sell much of her overstock to ferrotungsten manufacturers at a great loss.

Another interesting fact developed during the year. Improvements in electric-furnace processes for making ferrotungsten resulted in a greater demand for California and Nevada scheelite than for Colorado ferberite, and the premium that used to be paid for the latter was now paid for the scheelite.[1]

Among foreign producers, considerable progress was made in South American tungsten mines. Sweden enters the tungsten field for the first time this year and reports her first 20 tons of concentrates.

In the table below the weights are given in short tons of concentrates of 60 per cent. tungstic acid, WO_3, which is the commercial basis in this country.[2]

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES (a)
(In tons of 2000 lb., 60 per cent. WO_3)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1909	1,619	$614,370	$379	1914	990	$435,000	$439
1910	1,821	832,992	457	1915	2,332	4,100,000	1,760
1911	1,139	407,985	358	1916	5,923	12,075,400	2,040
1912	1,330	502,158	377	1917	6,144	6,783,400	1,100
1913	1,537	672,118	438	1918	5,041	6,802,000	1,349

(a) F. L. Hess, U. S. Geol. Surv.

The average price per unit of WO_3 was $24.33 for wolframite and $24.96 for scheelite.[3] At the very end of the year wolframite of good quality that carried more than 60 per cent. WO_3 was offered in New York for $12 per unit.

The total consumption of tungsten ore in the United States in 1918 amounted to 16,500 short tons, the largest consumption in the history of our industry. The importations broke all previous records. The production of ferrotungsten in 1918 was 2142 long tons.

TUNGSTEN ORE IMPORTS INTO THE UNITED STATES, 1918

Country.	Long Tons.	Value.
Portugal	24	$17,760
Argentina	479	730,722
Chile (mainly Bolivian origin)	1,116	1,209,864
Peru	1,631	1,488,516
Japan	1,215	1,700,332
China	5,165	4,808,358
Mexico and other countries	732	1,453,685
Total	10,362	11,409,237

The imports of ferrotungsten and tungsten metal amounted to only $8 in value in 1918. The exports of tungsten metal and alloy amounted to 1,232,260 lb., valued at $2,545,087, compared with 2,323,811 lb. valued at

[1] See under *California* and *Colorado* below.
[2] In Great Britain it is 65 per cent. WO_3.
[3] Chas. Hardy, *Eng. Min. Jour.*, Jan. 11, 1919.

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$4,122,653 in 1917. About two-thirds of our imports of high-speed steel before the war came from Germany, the tungsten used in its manufacture being largely of British origin.

United States

Alaska.—The tungsten industry of Alaska dates from the fall of 1915, when the demand for tungsten ores was phenomenally high and prices per unit had jumped from about $8 to $43 in November. According to J. B. Mertie, Jr.,[1] there are two workable scheelite lodes on the Ridge between Fish and Smallwood Creeks, Fairbanks district. The country rock consists largely of crystalline limestone, extensively silicated at certain horizons. The silicated portions contain calcite, pyroxene, hornblende and quartz. Hornblende schist and mica schist also occur in the near vicinity. The scheelite occurs as disseminated deposits in mineralized zones or as ore shoots in the country rock. On Fairbanks Creek adjoining the Mizpah mine the country rock is quartzite schist and the scheelite is present in a quartz vein; it is really a gold-tungsten vein for it contains both gold and scheelite. Along the northeast side of Tungsten Gulch, a head-water tributary of First Chance Creek, scheelite occurs in stringers of soft decomposed iron-stained schist. Here gold is likewise present; the scheelite mineralization seems to have taken place before the formation of the gold quartz veins. Other tungsten localities are on the divide between First Chance and Steele creeks, on the southwest side on Tungsten Gulch and at the head of Engineer Creek.

During 1918 tungsten was produced in the Fairbanks district and Seward Peninsula, but the total output was only about 12 short tons of 60-per cent. concentrates, valued at $22,000, compared with 47 tons in 1916 and 32 tons in 1917. A new vein of scheelite was discovered near Sitka.[2] It appears that scheelite is fairly well distributed throughout the territory of Alaska.

Arizona.—The main tungsten-producing counties in the State are Cochise, Pima, Mohave and Yavapai. According to F. L. Hess of the United States Geological Survey, the output of concentrates in Arizona was equivalent to about 213 short tons, 60 per cent. WO_3 basis, valued at $245,000. All three minerals, huebnerite, wolframite and scheelite were produced. In the Yucca district both tungsten and molybdenum occur. In some places copper carbonate and sulphides occur in close relation with the wolframite, but in no case are they intimately mixed with the latter.

In Yavapai County there are three districts of importance, Tule Creek, Tip Top and Eureka. The Tip Top mine is an old silver mine;

[1] "Lode Mining in the Fairbanks District, Alaska." U. S. Geol. Surv. *Bull.* 662-H.
[2] F. L. Hess, U. S. Geol. Surv.

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the tungsten ore used to be regarded as "black jack" and thrown on the dump. The Tip Top Leasing Co. issued a statement on the cost of concentrate production in 1917 and 1918.[1]

This cost amounted to $31.84 per unit, in which mining averaged $3.63, hauling, $4.54, and milling, $6.81 per unit.

In Pima County the district of importance is that of Arivaca, locally called the Las Guigas district. Huebnerite accompanied by wolframite and a little scheelite occurs in quartz veins.[2]

In Cochise County, in the Dragoon district, huebnerite accompanied by small quantities of scheelite occurs with fluorite in quartz veins cutting granite and in placers derived from these veins.

California.—California is the largest scheelite producer in the world and second largest tungsten-concentrate producer in the United States. Her production in 1918, according to F. L. Hess, totaled 1791 short tons of 60 per cent. WO_3 concentrates, as compared with 2781 tons in 1917 and 2171 tons in 1916.

In San Bernardino County the Atolia deposits are in more or less continuous fissures in a granite and the scheelite occurs mixed with quartz. In some localities scheelite occurs associated with small basic dikes in granite rock; and in other localities it is found in metamorphosed limestone, at or near contacts. The famous mine of the Atolia Mining Co. at Atolia made a much smaller output in 1918 than in 1917, but was still the largest individual producer in the United States.

In Inyo County, north of San Bernardino County and bordering on the State of Nevada, the Standard Tungsten Co., at Bishop, which had been working contact-metamorphic deposits, ran out of ore, and after re-treating a part of the tailings closed its mill.[3] The Bishop deposits are scheelite associated mainly with garnet, epidote, and quartz. The Pine Creek Tungsten Co. began active work on a contact-metamorphic deposit about 25 miles northwest of Bishop at an altitude of 11,000 ft. The country is very rough and steep and many miles of road had to be constructed. It is expected that the mill will be put in operation in 1919. The altitude is so high that during a large part of the year snow hampers operations unless they are carried on under cover. The mill of the company was completed and has a capacity of 300 tons of ore per day.[4]

In Nevada County the Grass Valley tungsten district is about 40 miles north of Sacramento. The mineral is chiefly scheelite.

In Kern County the Ratcliffe mill at Randsburg is equipped with a Hamill ore feeder and the Overstrom Universal concentrator table.[5]

[1] Meeting of the U. S. Tariff Commission, Denver, June 17, 1918. *Chem. Met. Eng.*, July 1, 1918.
[2] MINERAL INDUSTRY, **25**, 723.
[3] F. L. Hess, U. S. Geol. Surv. *Press Bull.*, Jan. 23, 1919.
[4] *Min. & Oil Bull.*, Nov., 1918, contains an interesting detailed account.
[5] *Min. Sci. Press*, **116**, 710 (1918).

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The recovery is better than 85 per cent. and the capacity averages 30 tons in 24 hours. The total cost of the mill was $4000. The tungsten deposits of Kern County are geologically a part of those of the Atolia district.

Colorado.—Colorado regained its lead in 1918 as the largest tungsten-producing state with 1910 short tons of ferberite.[1] The production in 1917 was 2707 tons and in 1916 2400 tons, all figured to 60-per cent. concentrates.

Boulder County, as in the past, was the principal source of the mineral in 1918. Ferberite was taken from the larger mines in quantity comparable with that mined in 1917, but the output from the lesser mines was so much smaller that the total dropped nearly a third. The Wolf Tongue Mining Co. had bonanza ore in its Cold Spring mine and was the largest producer in the county.[2] George E. Collins[3] points out that the last year of the war was probably the most disastrous which the mining industry of Colorado as a whole ever experienced. Small producers in Colorado have been more unfavorably affected than those of other states due to great scarcity of labor and, among other causes, to the fact that the mining industry of Colorado depends essentially on cheap smelting and freight rates. By the increase in these, a great quantity of low-grade ore became unprofitable, and much high-grade ore, which occurs as bunches together with the low-grade, was left unworked in consequence. Another contributing factor was the introduction of large shipments of cheap Chinese ores, as pointed out above. It was brought out at the Tariff Commission hearing[4] that the production cost per unit of 60-per cent. concentrate in Colorado, $15 to $33 per unit, was twice that of California and Nevada. The total cost of Chinese ore laid down at New York was $11.60. Warren F. Bleeker of the Tungsten Products Co., Boulder, stated that whereas ferberite had always been considered the best material for the electric-furnace manufacture of ferrotungsten, scheelite was now being used successfully and was commanding a premium which formerly had been commanded by ferberite. The high phosphorus of the Boulder County concentrate necessitated refining which was not necessary with scheelite.[5]

Some of the active producing mining companies in Colorado during 1918 were the Wolf Tongue Mining Co., at Nederland; the Vasco Mining Co. at Tungsten; the Primos Chemical Co. at Lakewood; the Rare Metals Co. at Rollinsville; the Black Metal Production Co. at Boulder; the Tungsten Products Co. in Boulder Canyon; and the Red

[1] F. L. Hess, U. S. Geol. Surv.
[2] U. S. Geol. Surv. *Press Bull.*, Jan. 23, 1919.
[3] *Eng. Min. Jor.*, Jan. 18 1919
[4] *Min. Sci. Press*, July 6, 1918.
[5] *Chem. Met. Eng.*, July 1, 1918.

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Sign Mill at Ferberite.[1] The high-grade tungsten ore (ferberite) is usually found in very narrow seams or in comparatively small lenses, involving maximum development work. The most important country rock is biotite-hornblende granite. Most of the mines are found in the granite and the more granitic parts of the gneiss. The ferberite occurs in finely crystallized compact masses and also in well-developed crystals. The absence of cassiterite, tourmaline, and other common associates of tungsten is noteworthy.

Besides those in Boulder County, there are tungsten deposits in Gilpin, San Juan, Lake, Park, Eagle and Chaffee counties.

Connecticut.—No reports have been received of any activities in 1918 in the tungsten district of Long Hill and Trumbull. The output of Connecticut in the past has been insignificant.[2]

Idaho.—Tungsten occurs in Idaho in widely scattered districts over the entire State: scheelite in the Coeur d'Alene district, Kootenai and Shoshone counties, in the north; wolframite and huebnerite in the Patterson Creek district in Lemhi County in the east, and wolframite near Corral in Blaine County in the south.[3] New deposits were uncovered in the Coeur d'Alene district during 1918. C. T. Kennan[4] recounts some of the early history of tungsten mining in Idaho, telling how scheelite was met with in all of the gold veins of the north years ago and was looked upon as heavy spar and considered an "abundant nuisance," since it frequently scraped the amalgam plates, carrying off the mercury, amalgam and gold along with the tailings into the creek, thereby causing large losses in gold milling. At several of the gold mines, notably at the Golden Chest, old dumps and stumps were partially worked over during the last three years. The Golden Chest recovered about $100,000 of scheelite in this way. A rich zone of scheelite occurred in the "Klondike Shoot," about 900 ft. long, of the Golden Chest mine. The scheelite itself does not carry gold, the gold being in the quartz and associated iron minerals. The Coeur d'Alene scheelite is of exceptional purity and a premium of $10 per unit was paid in 1918 over current prices. Kennan discovered a new scheelite vein crossing Pony Gulch. It is a contact vein in quartz and quartzite, lying between quartzite and slate with several igneous dikes running nearby and parallel to it.[5]

No production is reported for 1918 and only 2 tons was reported in 1917, against 101 tons in 1916.

Nevada.—Since 1915 Nevada has been one of the most important

[1] Geo. B. Young, *Eng. Min. Jour.*, Jan. 11, 1919.
[2] For details cf. MINERAL INDUSTRY, **25**, 726.
[3] MINERAL INDUSTRY, **24**, 691.
[4] *Salt Lake Min. Rev.*, Dec. 15, 1918.
[5] For a description of the mining district of Idaho, see *Bull.* 166, Dept. Interior, 1919, by Varley, Wright, Soper and Livingston.

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tungsten-producing states in the Union. In 1918 Nevada was the third largest producer. According to F. L. Hess the output in 1918 totaled 885 short tons of 60-per cent. concentrates, compared with 689 tons in 1916 (the previous high record) and 143 tons in 1917. One of the remarkable developments of 1918 was the large production of scheelite in the Great Basin region from the contact-metamorphic deposits, limestones altered by solutions accompanying intrusions of granite.[1] Much of the larger part of the ore mined in Nevada, in fact all reported except that from the Tungsten Dyke mine at Sodaville, was taken from contact-metamorphic deposits. The deposits at Bishop, Calif., also furnished a considerable quantity. Altogether the contact-metamorphic deposits gave an output of 1413 short tons of concentrates. In the Eugene mountains, about 7 miles northwest of Mill City, the Nevada Humbolt Tungsten Mining Co. erected mills which began work late in the year. A pipe-line 22,000 ft. long, to bring water from wells in the valley of the Humbolt River, two pumping stations to lift the water more than 1100 ft. to the mines, and a power line 32.5 miles long to bring electricity to them were built by the Mill City Development Co. A tramway, 3.5 miles long, with a gasoline locomotive and steel cars, hauls the ore of the Mill City Mining Co. to the Pacific Tungsten Co.'s mill. The Humbolt County Tungsten Mines and Mills Co. at Toulon treated ores from its own mines and from a number of other properties. The Pacific Tungsten mill has a capacity of 100 tons and was erected at a cost of $100,000.[2] According to president William J. Loring, of the Pacific Tungsten Co., the territory controlled by the company covers about 600 acres. The property consists of two large groups of claims.

South Dakota.—A splendid detailed treatise on "The Occurrence, Chemistry, Metallurgy and Uses of Tungsten" was published during the course of the year by J. J. Runner and M. L. Hartman.[3] This treatise covers primarily the tungsten deposits of South Dakota. "The presence of tungsten minerals in the pegmatites and quartz veins in the Southern Black Hills and in the Nigger Hill district has been known practically since the development of those districts for tin, which began in the early eighties. The tungsten deposits of the Black Hills, so far as known, are confined to three districts. The largest area is in the vicinity of Harney Peak, largely in the western and northern parts of the granite area. A second area lies in the vicinity of Lead and Deadwood in the Northern Hills and a third area in the Nigger Hill District 15 miles west of Lead." The Homestake Mining Company is the chief producer and during the year considerable wolframite was produced from the replacement deposits

[1] U. S. Geol. Surv. *Press Bull.*, Jan. 23, 1919.
[2] *Min. Amer.*, July 15, 1918.
[3] *So. Dak. School of Mines Bull.* No. 12, Rapid City, S. D.

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at Lead. The production of other tungsten ores in the Black Hills was so small as to be negligible.[1] The total tungsten production for 1918 amounted to 201 tons of 60 per cent. WO_3 basis, of which the Homestake mine furnished almost all.[2] The production in 1917 was 270 tons and in 1916, 239 tons.

Other States.—E. R. Zalinski of Salt Lake City reports that a few tons of scheelite concentrates were shipped in 1918 from near Lucin in Boxelder County, Utah, and also from Deep Creek, the latter being produced by Wilson Brothers. About 2 tons of huebnerite concentrates originated from the Blue Grouse Mountain district near Deer Park, Washington. About ten tons was shipped from New Mexico.[3]

UNITED STATES PRODUCTION ACCORDING TO STATES
(Short tons of 60-per cent. concentrates)

	1916.	1917.	1918.		1916.	1917.	1918.
Alaska	47	32	12	Montana	.....	1	.....
Arizona	218	150	213	Nevada	689	143	885
California	2,171	2,781	1,791	New Mexico	16	12	10
Colorado	2,401	2,707	1,910	South Dakota	239	270	201
Connecticut	3	.....	.....	Utah	6	11	3
Idaho	101	2	12	Washington	8	2	2
Missouri	2	50	.....	Totals	5,923	6,144	5,041

TUNGSTEN IN FOREIGN COUNTRIES

NORTH AMERICA

Canada.—According to the Canadian Department of Mines about 3 tons of 60 per cent. WO_3 concentrates were produced in Canada in 1918. The major part of this production was in Manitoba. Small quantities were derived from Nova Scotia and the Yukon district. The Acadia Tungsten Co. at Burnt Basin, New Brunswick, shipped 17 tons of wolframite concentrates early in 1918, but these were produced in 1917.[4]

Mexico.—The Nogales district, State of Sonora, is a very wealthy mineral area. Copper, silver, gold, graphite, tungsten, molybdenum and antimony are all produced in commercial quantities. Mexico has been in the tungsten market ever since the sudden jump in the price of tungsten in the fall of 1915. Near Huepec, Sonora, tungsten occurs as scheelite associated with copper; in the district of Sahuaripa, Sonora, 150 miles south of the Texas line, scheelite occurs together with molybdenite. Practically all of the Mexican output reaches the United States. In 1918 the State of Sonora exported 64 tons valued at $47,887, as compared with

[1] F. L. Hess, U. S. Geol. Surv.
[2] *Eng. Min. Jour.*, May 24, 1919.
[3] See MINERAL INDUSTRY, **26**, 707 (1917).
[4] See MINERAL INDUSTRY, **26**, 708 (1917).

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90 tons valued at $83,373 in 1917.[1] The total exports of tungsten concentrates from Mexico amounted to about 265 metric tons of 60-per cent. concentrate equivalent.

New deposits of tungsten (scheelite) were uncovered in the Yaqui River district below Tonichiari, Sonora. An American concern from Douglas, Arizona, has taken an option on the property.[2]

South America

Argentina.—Tungsten is next to petroleum the most important mineral of Argentina. Previous to the war the output of tungsten was controlled by the Germans. Since then the United States and allied countries have bought the entire product. Exports in 1917 amounted to 2,175,119 lb. of 65 per cent. wolframite, valued at $816,623, an increase of 498,749 lb. over 1916, but a decrease of $198,149 in value on account of lower prices.[3] The exports to the United States in 1917 totaled 260,700 lb., valued at $97,885. The tungsten production for 1918 is estimated at 1000 metric tons, 479 tons of which entered our ports.

The tungsten deposits of Argentina, with a single exception, are confined to the pampa ranges, in which they have a wide distribution.[4] Both scheelite and wolframite occur, but the latter has so far predominated in all shipments. The Provinces of San Luis and Córdoba are the most important tungsten producers.[5] Some of the ore is also derived from the Provinces of La Rioja and Catamarca. The most important mine is the Los Condores, about 115 kilometers northeast of San Luis. According to Miller and Singewald the deposits occur in regions of crystalline schists and metamorphosed Paleozoic sediments that have been intruded by granites and granodiorites of different ages, pre-Cambrian to post-Silurian. The post-Silurian granites are accompanied by numerous pegmatites with which the veins are genetically associated. The most abundant filling of the veins is quartz and mica. Veins of quartz and mica without cassiterite or tourmaline are found at a number of localities in San Luis and Córdoba. The Loma Blanca veins on the western slope of the Cerro del Morro contain considerable fluorite, elsewhere scarce or completely lacking. The tourmaline-bearing tungsten veins include those of Los Condores, which yield wolframite and small quantities of scheelite. The principal Los Condores vein is 600 meters long and has an average width of 80 to 100 centimeters. Mazán in La Rioja is the only example of the occurrence of cassiterite and wolframite in the same deposit. The country rock is a reddish, coarse to medium-grained,

[1] *Suppl. to Comm. Rept.*, Apr 28, 1919.
[2] *Eng. Min. Jour.*, July 13, 1918.
[3] W. Henry Robertson, *Suppl. to Comm. Rept.*, Feb. 27, 1919.
[4] Miller and Singewald, "The Mineral Deposits of South America," McGraw-Hill, 1919.
[5] See Beder, Proceedings Second Pan-American Scientific Congress, 8, 905-923, Washington, 1917.

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porphyritic older granite, with basic segregations consisting chiefly of biotite and a red to yellowish gray younger granite in which the mica is almost entirely muscovite and which is characterized by acidic segregations of quartz and tourmaline.[1]

Ralston C. Sharp published a report of his survey of "The Wolfram Deposits of Argentine."[2] He points out that many of the deposits occur at altitudes of 2000 to 5000 ft. and that among the associated minerals bismuthinite (Bi_2S_3) is rarely absent. At Mazanin, about 35 kilometers north of La Rioja, a small French company was operating. The Morro mine east of San Luis was being worked by an American syndicate. "Speaking generally of the Argentine deposits, the veins appear to contain from 0.5 to 1.5 per cent. of wolfram in unevenly distributed crystals, lumps and slabs, weighing up to 50 kilograms. Mining methods as a rule are of the crudest. No stoping is attempted, although good props can be obtained. Double-handed drilling is the custom and miners, generally Spaniards and Italians, are paid from $1.10 to $1.50 per day."[3]

Bolivia.—During the war the tungsten industry of Bolivia was greatly extended in consequence of high prices. The production of the Republic in 1917 outstripped that of Portugal and rivaled that of the United States and that of Burma. According to the Bolivian customs officials, an equivalent of 4150 metric tons of 60 per cent. WO_3 concentrates was exported in 1917, valued at £585,201. The production of 1918 is estimated at 3000 metric tons. The United States imported 1250 tons (mainly via Chilean ports).

A detailed account of the tungsten industry of Bolivia was published by G. F. J. Preumont.[4] He points out that La Paz is the most important district as a tungsten producer. The other three districts of note are Oruro, Potosi and Cochabamba. The principal mines in the department of the La Paz are Palca or Yungas, Quime or Inquisivi. The common mineral is wolframite, although scheelite is also met with in paying quantities. The richest veins are along the line of the Eastern Cordillera, running from north to south. The mountains consist chiefly of metamorphic schists and slates. The wolframite occurs in granite, quartzite and slate. Most of the wolfram mines in Bolivia are situated at great altitudes, involving trying climatic conditions and extremely difficult means of access. Transportation is solely by means of pack animals. Almost every mine is worked on the contract system. American interests show signs of development, but as Miller and Singewald[5] emphasize,

[1] Miller and Singewald, *op. cit.*, p. 64.
[2] *Min. Mag.*, May, 1918, p. 230–4.
[3] Sharp, *op cit.*, p 233. Full details are given.
[4] *Bull.* 173, *Inst. Min. Met.*, Feb. 13, 1919.
[5] *Op.cit.*, p. 86.

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"most of the tungsten deposits are of such low grade that they cannot be worked in normal times." The mode of occurrence and geologic features of the tungsten deposits of Bolivia are identical with the corresponding features of the tin deposits. A number of poorly paying tin mines became prosperous tungsten mines before the close of the war.

Brazil.—According to Consul General A. L. M. Gottschalk at Rio de Janeiro, a mine 10 miles from the city of Lavras in the State of Rio Grande do Sol was producing at the rate of 1000 tons of tungsten concentrates per annum immediately preceding the war and shipping the product to Krupp in Germany. Nothing further has been made public regarding this mine and within the last three years the shipments from Brazil have amounted to but 2 to 5 metric tons of 60-per cent. concentrates per year.[1]

Chile.—Tungsten is found in Chile near Cupane at an elevation of 10,000 ft. above sea level. Most of the concentrates that pass through Chilean ports are of Bolivian origin. Chile's production amounts to but 5 to 10 tons per annum.

Colombia.—Colombia exported to the United States several tons of tungsten concentrates in 1918. Details as to the origin of these have not been published. They may have been trans-shipped from other parts of South America.

Peru.—The tungsten industry of Peru has steadily increased in importance within the last six years. In 1912 the total production amounted to 214 metric tons of 60-per cent. concentrates. In 1916 it was 532 tons, valued at $1,490,000, and in 1917 it increased to almost 1000 tons, valued at $1,056,000.[2] The production for 1918 is estimated at 1800 metric tons, of which 1631 tons was imported into U. S. The tungsten resources of Peru are looked upon as the most important of South America. According to Miller and Singewald[3] the Peruvian tungsten is found principally in the district lying on both sides of the Pelagatos River. The tungsten occurs chiefly as huebnerite in a quartz gangue, often mingled with tetrahedrite and occasionally galena. Sandstones and shales have been upheaved and contact-metamorphosed by a granite intrusion which along the contact has greisen structure. The river has cut through the granite mass and exposed tungsten deposits on each side, but the greater mineralization is on the Huaura side.

EUROPE

Austria-Germany.—Wolframite occurs in the Erzgebirge region and among the most important localities are Zinnwald, Altenberg, Schmiede-

[1] See MINERAL INDUSTRY, 26, 709 (1917).
[2] *Comm Rept.*, Feb. 15, 1919.
[3] *Op. cit.*, p. 466.

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berg, Geyer, Schlaggenwald, Ehrenfriedersdorf, Falkenstein and Bergen.[1] In 1912 the production of the two empires totaled 167 tons. Since then no authentic figures have been published. The production for 1918 we estimate at 300 tons of 60-per cent. concentrates. On the basis of a report appearing in the *Frankfurter Zeitung* of Aug. 24, 1918,[2] one would be inclined to estimate the production at 1200 to 1500 tons; but this probably covers a 4-year period. The smelting was carried out in Saxony.

England.—England continues to control over one-half the tungsten production of the world. The vast importance of the tungsten industry to the safety and progress of the British Empire was very ably demonstrated at the "New British and Key Industries Exhibition" held at London in the early fall of 1918.[3]

The production of tungsten in the British Isles in 1918 amounted to about 400 metric tons (calculated upon a 60 per cent. WO_3 American basis; English basis is 65 per cent. WO_3). The Cornwall and Devon tin-tungsten mines were the chief producers. A detailed account of the manufacture of tungsten at the Widnes is given by J. L. F. Vogel, founder of the British tungsten industry.[4] According to the British Board of Trade England produces annually 20,000 tons of high-speed and other tungsten steels, 8000 tons being consumed in England and the balance exported. The normal peace requirement is given as 8000 tons of tungsten steel, or an equivalent of 1200 tons of tungsten metal. It is stated that 2¼ tons of 65-per cent. concentrates are required to produce the equivalent of 1 ton of tungsten metal.[5] With the signing of the armistice and the cancelation of government shell and other munition contracts, the steel makers were soon overstocked with tungsten. As the British Government had agreed to take all the ore from her colonies at a fixed price for 6 months after signing of peace, overstocking of ore continued. It is estimated that England is well supplied for two years to come.[6] By the close of the year the Government reduced the price to the tungsten and ferro manufacturers to £1 10s. per unit of tungstic acid. The price of ferrotungsten and tungsten metal fell to 2s. per lb. of metal content.[7]

France.—Wolframite with cassiterite occurs in the Haute Vienne district, and scheelite in small quantities is found at Meymac and Framont in the Vosges Mountains. The output of the Republic has been at the rate of 200 to 300 tons of 60-per cent. concentrates per annum; however, no official reports have been published since the outbreak of the war.

[1] Hans Mennicke, "Die Metallurgie des Wolframs."
[2] *Comm. Rept.*, Oct. 4, 1918.
[3] See Handbook, The Keys of Industry, publ. by Tariff Reform League, London.
[4] *Min. Mag.*, Jan., 1919.
[5] *Min. Jour.*, June 22, 1918.
[6] *Eng. Min. Jour.*, Apr. 12, 1919.
[7] John M. Savage, *Comm. Rept.*, Mar. 10, 1919.

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Italy.—Within the last few years the mining industries of Italy have been flourishing. But practically no tungsten was found, according to La Gazzetta Mineraria.[1] Italy produced 7 tons of tungsten concentrates in 1916 and 1 ton in 1917. Tungsten occurs as scheelite in the antimony deposits of Sardinia.[2]

Portugal.—The production of tungsten in Portugal in 1918 is estimated at 1500 tons of 60-per cent. concentrates compared with 1600 tons in 1917 and 1400 tons in 1916. A detailed account of the principal tungsten mines of Portugal was published by F. W. Foote.[3] Among the 30 mines listed the Borralha, Panasqueira, Moimenta, Montado de Adoria and Cabeco de Paredes are the largest producers. Portugal is the largest tungsten state in Europe; her output of the mineral is equal to that of all the other states put together. The Borralha mines are situated in Tras Os Montes. The Panasqueira group in Beira Alta is being operated by a British concern. About 50 miles north of the Panasqueira mine in the Vizeu district an American company has been very active. The Portuguese tungsten occurs mostly as wolframite and huebnerite, in quartz veins of the fissure type cutting both granites and schists. In the Viseu district the ore is derived from alluvium deposits besides from fissure veins in granite. Many of the tungsten mines of Portugal produce tin concentrates as a by-product. Portugal exported 24 tons of tungsten concentrates to the United States in 1918.

Russia and Siberia.—According to the Russian Mining Bureau 108 metric tons of tungsten concentrates (60-per cent. basis) was produced in 1917. Tungsten is found at Boevke in the Urals in the Province of Perm. According to Soutschinsky[4] tungsten deposits in Siberia are located at the following 4 localities: in the province of Transbaikalia (east of Lake Baikal); Bukuka mountain, 66 miles north of Borzia; near the station of Tchara Nor on the Transbaikal Railroad; near Oldanda village; and in the vicinity of Sherlof mountain, 17 miles northwest of Borzia. In the Bukuka mountain there are three shafts, 25 to 30 ft. deep. The mineral is wolframite occurring in quartz veins, some of which are 15 in. thick. The Baikal deposits resemble those at the Boevke mines in the Urals. Some of the quartz veins contain molybdenite and lithium mica. The granite often resembles beresite. Before the revolution the production of wolframite ore in Transbaikalia amounted to about two to six tons per month. Since then the industry has practically ceased to exist.[5]

Spain.—Tungsten occurs in the following provinces, arranged in the

[1] *Comm. Rept.*, Feb. 28, 1919.
[2] *Min. Jour.*, Mar. 9, 1918.
[3] *Eng. Min. Jour.*, July 13, 1918; see also *Comm. Rept.*, July 24, 1919.
[4] *Comm. Rept.*, Jan. 23, 1919.
[5] *Comm. Rept.*, Jan. 23, 1919.

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order of their production: Zamora, Pontevedra, Salamanca, Badajos, Orense, Coruña and Almeria.[1]

The production, calculated upon a 60 per cent. WO_3 basis, was 200 metric tons in 1915 and 170 metric tons in 1916.[2] The wolframite deposits of Zamora province were very rich for the first few feet below the surface, but later wide sterile zones were encountered, making the future of the mines in this province uncertain.[3] The mineral industry of Spain in 1917 was a flourishing one and the total mineral products were valued at 140 per cent. of those for 1916.[4] The tungsten output of Spain in 1917 and in 1918 is estimated at about 300 metric tons of 60 per cent. WO_3 concentrates per annum.

Sweden.—This is the first year that Sweden enters as a tungsten-producing country. The Stockholmes Superfosfat Co. has begun to exploit large and rich deposits of wolframite and scheelite near Yxsjö in Bergslagen and there are great hopes that there will be sufficient to supply all Sweden's needs, which are estimated at 20 tons a year. Since 1916 no tungsten has been imported into Sweden.[5]

Asia

Banka and Billiton Isles.—These Dutch Islands lie south of Singapore and east of Sumatra. Cassiterite and wolframite—about 2.5 per cent. tin and 1.0 per cent. WO_3—are found disseminated in greisen. Two mills treated about 200 tons of ore daily.[6] The production of 60-per cent. tungsten concentrates in 1918 is estimated at 750 metric tons, practically all of which was exported.

Burma.—In the years preceding the war the annual production of tungsten in Burma was about 2000 metric tons, or about twice that of the United States. In 1915 the output reached almost 3000 tons and Burma was the largest tungsten producer of the world. Since then Burma has been turning out from 4000 to 4200 tons per annum, and in 1918 with a production of 4000 tons was third largest producer of the world. Although Burma is primarily an agricultural country, of late years there has been a very remarkable development in the mining industries. Wolframite associated with the ore occurs in extreme southeastern Burma, the narrow strip west of Siam. The important centers are Tavoy, Mergui, Moulmein and Thaton. Considerable quantities of tungsten are furthermore produced in the Southern Shan States due north. Most of the mine laborers are Chinese. The methods of mining differ according

[1] *Estadistica minera de España*, Año, 1915, p. 40 (1917).
[2] Consul E. E. Palmer, at Madrid.
[3] C. B. Hurst, *Comm. Rept.*, Mar. 3, 1919.
[4] *Comm. Rept.*, Jan. 3. 1919.
[5] *Comm. Rept.*, Oct. 15. 1918.
[6] *Min. Sci. Press*, June 8, 1918.

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to whether alluvial or lode is attacked. The Tavoy lodes are invariably quartz with a little mica. The wolframite crystals are scattered irregularly through the quartz. Among the important mines are the Pagaye, Hermingyi, the Hinu Choung (mostly tin), Hpaungdaw mines, Kanbauk, Mèke, and Pè mines. The Tavoy district produces about 85 per cent. of the Burmese tungsten. What promises to be an important field was discovered in 1918 in the district of Yamethin, in the upper valley of the Sittang River.[1] Briggs evaluates the tungsten production of Burma at $1,383,890 in 1915; $2,349,571 in 1916; and $2,975,360 in 1917.

According to the Chief Inspector of Mines of India[2] considerable progress has been made in hydraulic mining of tungsten in Burma. Furthermore there are now four air-compressor plants operating machine drills. One of the latest projects is a reservoir with a capacity of 550,000,000 gal. which is to supply water under a head of 1800 ft. to turbo generators so as to drive some of the large mine and dredging machinery by electricity. The installation of the magnetic separator at Tavoy has greatly assisted concentration and separation of the ores. Transportation facilities have been greatly improved throughout the tungsten field.

As regards the geology of the Burma tungsten deposits see MINERAL INDUSTRY, **26**, 713 (1917).[3] W. R. Jones[4] offers a very plausible explanation for the occurrence of tungsten in some manganese ores.[5] In Lower Burma, Siam and the Malay States it is common to find wolframite so completely weathered that only deposits of the oxides or hydroxides of manganese, iron, and tungsten remain. So unstable is wolframite in Burma that at the foot of the hills in which there are tungsten veins which are being worked, it is the exception to find any wolframite in the alluvial deposits, although they are common in the detrital deposits. On one of the alluvial deposits where tin ore is being recovered, the latter carries less than 1 per cent. of wolframite in the concentrates. Analysis of a sample of weathered ore from a wolframite lode showed MnO, 90.38 per cent.; WO_3, 4.2; Al_2O_3, 4; SiO_2, 1.80 per cent.[6] And a sample of wolframite right next to this sample assayed 70 per cent. WO_3.

China.—China entered the field as a tungsten producer in 1916, when 110 metric tons was shipped. In 1917 her production increased in leaps and bounds and in 1918 over 9000 metric tons of 60-per cent. concentrates, valued at $850 per ton, was exported. China's record is one of the most noteworthy in the tungsten industry of 1918. The exports to the United States in 1918 amounted to 5165 short tons valued at $4,808,358.[7]

[1] Consul L. P. Briggs, *Comm. Rept.*, Nov. 19, 1918.
[2] *Comm. Rept.*, Jan. 27, 1919.
[3] See also *Min. Mag.*, Feb., 1919.
[4] *Eng. Min. Jour.*, Nov. 2, 1918.
[5] See W. S. Palmer, *Eng. Min. Jour.*, Apr. 27, 1918.
[6] H. R. Pepper, *Eng. Min. Jour.*, Apr. 27, 1918.
[7] George E. Anderson, *Comm. Rept.*, Apr. 11, 1919.

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The best ore fields were only coming into production when the trade, because of an overstocking in the United States and Europe, fell off. According to Consul General Anderson,[1] a large field on the border of the Kwangtung and Kwangsi Provinces was located and active development begun in July, 1918. Aside from the actual production of other fields in Kwangtung Province, the possible production of this new field unquestionably establishes South China as the chief source of the world's supply of tungsten in the future, for at the height of shipments in 1918 these fields, including the rich new deposits, were producing something like 1200 tons per month. The possibilities of the full development of this trade on a profitable basis are indicated by the fact that the first shipments of the ore from the South China field were made at about one-third the rate obtainable under later war conditions.

The new field is centered very largely around Sai Wah Mountain, in Kwangsi Province, not far from the Kwangtung Province border. The ore is carried by coolies over a route requiring from four to five days' travel and thence by boat down a small river to Shuichow, which is the head of railroad traffic on the so-called Canton-Hankow Railroad. Considerable ore also comes from districts to the east and is carried to the East River at Ting Nam and comes into the market by rail from Low Lung. Most of the ore mined in this richer district is from pockets in public or semipublic land, *i.e.*, land owned by the several neighboring villages. The ore is purchased in small lots by middlemen, and until the latter can know something of what future prices are to be they can not safely buy the lots of ore available. On the other hand, it is not always possible to demonstrate to villagers the real value of their ore.

During the opening weeks of 1919 export has been almost at a standstill because of a lack of orders at prices comparable with those obtained during most of the past year. There is no question but that the ore can be mined and shipped at a good profit at present prices, but until owners and operators of the mines understand what the normal or post-war level of prices may be, it is likely that little mining will be done. The Chinese deposits are alluvial and are now probably mined more cheaply than any others in the world.

Federated Malay States.—Tungsten is found in the states of Perak, Selangor and Negri Sembilan. In 1917 the Non-Federated State of Kedah, northwest of Perak, also became a tungsten producer. Throughout the F. M. S. a large proportion of the tungsten minerals is recovered from detrital material and is associated with cassiterite. At Bukit Rumpian in Perak are some of the best-known lodes. Here the country

[1] *Loc. cit.*; see also MINERAL INDUSTRY, **26**, 714 (1917).

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rock is tourmaline-granite and is traversed by small quartz veins carrying cassiterite and wolframite. In Selangor practically all the wolfram-tin ore comes from places where there is a contact of granite and schist. On the contact the quartz veins carry mixed ore, and where they continue into granite they get richer in tin and poorer in tungsten.[1]

According to Government reports[2] the exports of tungsten ore from the F. M. S. for the year 1917 amounted to 830 metric tons on the 60 per cent. WO_3 basis, compared with 562 tons in 1916. In 1913 the production of tungsten in these states was only 250 tons, and accordingly the output has more than trebled since the outbreak of the war. The above figures include ore sent to the F. M. S. for treatment and then re-exported. The actual output of the F. M. S. mines in 1917 is recorded as 788 metric tons (60 per cent. WO_3 basis). Of the 830 tons exported about 370 tons were scheelite concentrates and the balance wolframite concentrates. In addition to the above, the Kubang Pasu district of Kedah exported 140 metric tons (60-per cent. basis).[3] The total therefore exported from the Federated and Non-Federated States was 970 metric tons in 1917 as compared with 580 tons in 1916. We estimate the actual production for 1918 at about 700 to 750 tons as compared with 788 tons for 1917.[4]

French Indo China.—Tonkin exported 250 metric tons of tungsten concentrates in 1917 compared with 164 tons in 1916 and 219 tons in 1915. The mineral is wolframite associated with cassiterite.

Japan.—The tungsten production of Japan, including Korea, rivals that of Portugal. It has become one of the most important mineral industries of the Empire. In Japan proper tungsten occurs in Yamaguchi Ken and in Ibaraki Ken. The output of concentrates in Japan proper was equivalent to about 550 metric tons of 60-per cent. concentrates, compared with 790 tons in 1917 and 850 tons in 1916.[5] The mines of Korea furnish about one-half of the Empire's total. Ferberite occurs at Kurasawa in the Province of Kai and huebnerite at Nishisawa in the Province of Shimotsuke. Furthermore, Japan also produced small tonnages in the Chin Chow district of the Kwangtung Leased Territory in southern Manchuria.

The total production of tungsten concentrates for the whole Empire was approximately 1400 metric tons in 1918, as compared with 1500 tons in 1917. The major part of the production was exported, 1215 tons being consigned to the United States.[6] The Japanese steel industry is develop-

[1] J. B. Scrivenor, *Min. Jour.*, **114**, 384, 406, 433.
[2] E. N. Gunsaulus, *Comm. Rept.*, Nov. 12, 1918.
[3] It is to be understood that the concentrates of the British colonies average 65 per cent. WO_3; we have converted all values to the 60-per cent. basis, which is standard in the United States, in order to compare productions easily.
[4] Compare also MINERAL INDUSTRY, **26**, 715 (1917).
[5] *Comm. Rept.*, Feb. 19, 1919.
[6] *Eng. Min. Jour.*, Mar. 15, 1919.

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ing by leaps and bounds and the home consumption of tungsten for high-speed steels is rapidly increasing.[1]

Siam.—C. C. Hansen, American Vice-consul at Bangkok,[2] reports that whereas formerly all of the tungsten was mined in the district of Nakawn Sritamaraj, within the past year paying quantities of mineral have been found in the district farther south. The production in 1917 was 634 metric tons, figured to 60 per cent. WO_3 basis, as compared with 468 tons in 1916. The production for 1918 we estimate at 525 tons. During the summer of 1918 the Siamese Government reduced the royalty on tungsten ore produced from 25 per cent. down to 10 per cent. ad valorem.[3]

The tin-tungsten mines in the Province of Nakawn Sritamaraj are operated by Chinese. The methods are still very primitive; most of the blasting is done by black powder and the crushing by hand.[4] No attempt is made to separate the cassiterite from the wolframite, the ore being sold and shipped as mixed ore. A good part of this mixed ore is transported to the Federated Malay States and to the Straits Settlements, where magnetic separators are installed. Scheelite lodes and alluvial deposits have been found in the Province of Trang, in the Amphurship of Hoyoet, and attempts were made to develop the deposits.

Australia and New Zealand

Queensland.—According to the Annual Report of the Under Secretary for Mines in the State of Queensland for 1918, fixed and satisfactory prices for wolframite and scheelite were maintained throughout the year in accordance with war regulations.[5] Methods of extraction were improved upon. There is good prospect that the 1918 prices will be maintained for the greater part of 1919. The State battery of Bamford, on the Chilagoe field, profitably treated not only quantities of low-grade ore which could not bear high transport charges, but repeatedly attracted higher-grade parcels from other centers. Owing to difficulties in obtaining equipment the plant of the Thermo Electric Ore Reduction Corp., Ltd., at Wolfram, could not be completed. A new and outstanding feature at many of the Queensland mines is their equipment with substantial and effective mining machinery. The principal mines acquired by the Thermo Corporation are Leisner's Wolfram Block, Murphy and Geaney, Larkin and Wade, Hillside, Forgetmenot, Hughes, Tulley and Mulligan, the foremost producers being the Larkin and Wade and the Tully mines. The tungsten minerals occur in white translucent quartz.

[1] *Comm. Rept.*, Oct. 3, 1918.
[2] *Comm. Rept.*, May 1, Nov. 18, 1918.
[3] *Comm. Rept.*, Nov. 18, 1918.
[4] *Comm. Rept.*, June 18, 1918.
[5] *Queens. Govt. Min. Jour.*, Mar. 15, 1919.

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Of the privately owned Queensland mines Welsby's Victory holds foremost place as chief producer of molybdenite and wolfram-bismuth. The Brandon Deeps continues to produce average-grade ore from its pipe, which has been remarkable for its consistency both in continuity of pitch and size. Wolframite with a little bismuth predominate in this mine. The Mount Carbine mines, now mostly held and operated by the Thermo Corp., have maintained their position of foremost wolframite producer in the North. An air compressor, jack-hammers and several rock drills were acquired and greatly expedited production. The small scheelite mines situated in the foothills of the Burton Ridge have doubled the output of the previous year and give promise of still increased yields for 1919. The newly discovered wolframite locality at Mount Perseverance, between Mossman and Mount Molloy, produced 10 tons of fair-quality wolframite ore. The total production of Queensland we estimate at 550 metric tons, figured to the 60 per cent. WO_3 basis, as compared with 500 tons in 1917.

New South Wales.—Three methods of concentration—table, flotation and magnetic—are in use at the Butler mine near Torrington, N.S.W. where a tin-wolfram-lead ore is being treated.[1] The lode is being worked by an adit level 920 ft. long and also by a main shaft. The new company started milling in July, 1916. On account of the lead in the concentrates, which is objectionable, a modified concentrating method had to be devised. The average assay of the concentrates was 53 per cent. Sn, 12 per cent. WO_3 and 5 per cent. Pb. Accordingly a Minerals Separation flotation unit was installed to take care of the lead and a magnetic separator to remove the wolframite.[2] The extraction by the wet concentration is 80 per cent. tin, 67.7 per cent. WO_3, and 66.0 per cent. lead. Owing to the high percentage of slime these values are considered excellent. In the secondary treatment, the tin-wolfram-lead concentrates are sent to the flotation machine, where the lead is floated off. The tin-wolfram product remaining is dried and treated by a magnetic separator of the "motor" type; this gives a marketable product when working on fairly coarse ores or concentrates, but it is not comparable to the Wetherill-type separator when dealing with fines, owing to the amount of retreatment required.

The tungsten production of New South Wales is estimated at 400 metric tons, 60 per cent. WO_3.

Victoria.—About 25 tons of concentrates was produced in Victoria.

Northern Territory.—The tungsten industry in Northern Territory is not very active, but a number of mines were being worked in 1918.[3]

[1] *Eng. Min. Jour.*, Sept. 21, 1918.
[2] See flow sheet, *Eng. Min. Jour.*, *l. c.*; also in *Chem. Eng. Min. Rev.*, **10**, 265–6, 1918.
[3] *Min. Mag.*, Feb., 1919.

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Many men were at work at Hatch's Creek and 16 tons of ore (wolframite) was sent away by camel team in May and 12.5 tons in June. Wolframite also occurs along the King River about 20 miles northeast of Marranboy. The Wolfram Camp mine was rated as one of the very best tungsten mines in Australia. Over £100,000 worth of wolframite was taken out by a few miners. A large quantity of the ore was bagged at the mine. The lower grade, and that containing copper, was taken to a concentrating mill. Besides tungsten, some hundreds of tons of copper ore was shipped. In order to test the lode at greater depth a tunnel was driven into the hill to cut the lode, and after driving 400 ft. the lode was reached, showing a width of 17 ft. containing 7 per cent. wolframite, besides paying copper quantities. The tungsten production of the Northern Territory in 1918 was about 500 metric tons, figured to the 60-per cent. basis.

New Zealand.—Scheelite occurs in many parts of the Dominion. One of the districts is at Glenorchy, northwest of Dunedin, and the other is at Macrae's Flat, about 50 miles north of Dunedin. The production of concentrates for 1918 is estimated at 400 metric tons, 60-per cent. basis.

Tasmania.—The 1918 production of Tasmania comprised 155.4 metric tons of wolframite concentrates valued at £27,239, and 216.0 tons of scheelite concentrates valued at £39,252. This is equivalent to a total production of 415 metric tons of 60-per cent. concentrates, or three times the production of 1916.

Africa

Rhodesia.—Owing to the great demand for tungsten for high-speed tools for munition factories, the Southern Rhodesia Geological Survey made a careful study of the deposits of wolframite and scheelite in Southern Rhodesia.[1] The known tungsten reefs lie within an east and west rectangular block of country of about 9.5 sq. mi. area, immediately north of Essexvale Siding. Sixteen distinct reefs are known. Both scheelite and wolframite occur. In the acid-dike type of reef wolframite is the chief tungsten mineral. In the gold quartz-vein type of reef scheelite occurs in very fine grains, concentrating as a dull gray or white powder in front of the gold in the pan. In a third type of reef tungsten is found associated with copper ores in quartz gangue. The deposits of Southern Rhodesia were first prospected in 1906 and in 1907 the equivalent of 192 metric tons of 60-per cent. concentrates was shipped. But since then the industry has lagged far behind. The returns for 1916 were 2.5 tons valued at £467, about 3 tons in 1917, and a similar quantity in 1918. In

[1] A. E. V. Zealley, *Bulawayo Chronicle*, May 18, 1917; H. B. Maufe, Short Report No. 4, Apr. 22, 1918, Bulawayo.

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June, 1918, the British Ministry of Munitions agreed to increase the price to 60s. per unit or £195 per metric ton of 65 per cent. WO_3 concentrates.[1] But in spite of this added inducement the production of tungsten, in common with other minerals of South Africa, decreased during the second half of the year.[2]

Transvaal.—Wolframite in small quantities has been found in various localities in the Transvaal. Scheelite occurs in appreciable quantities in the Stavoren Tin Mines, near the Olifants River, and in 1917 about 6 tons was produced. Some 2 tons of scheelite was picked up on the surface near Leydsdorp in 1916 and 3 to 4 tons in 1917, but capital was lacking for development of this deposit.[3] A little wolframite was met with in the quartz lodes on the farm Annexe Langverwacht near Capetown.[4]

WORLD'S PRODUCTION OF TUNGSTEN ORES
(Metric tons; 60 per cent. WO_3)

Country.	1908.	1913.	1914.	1915.	1916.	1917.	1918.
North America:							
United States	610	1,397	900	2,120	5,400	5,574	4,573
South America:							
Argentine	500	539	394	171	825	990	1,000*
Bolivia	170	564	276	850	3,288	4,150	3,000*
Peru	.....	300	196	371	532	1,000	1,800*
Europe:							
England	240	182	205	360	427	450*	400*
France	115	245*	200*	200*	200*	225*	200*
Germany-Austria	80	150*	220*	250*	300*	250*	300*
Portugal	620	800	967	933	1,418	1,596	1,500*
Spain	225	150	84	200	170	300*	300*
Asia:							
Burma	.....	1,732	1,868	2,883	4,123	4,200	4,000*
China	.....	.....	.....	.....	110	1,200	9,000*
Siam	.....	281	30	297	468	634	525*
Japan	200	297	195	439	1,260	1,500*	1,400*
Australasia:							
Queensland	470	543	435	640	460	500*	550*
New South Wales	245	209	220	100	310	400	400*
New Zealand	80	270	250	249	300	350*	400*
Total world production	3,555	8,000*	7,000*	10,500*	20,000*	22,500*	30,000*

Statistics reported by F. L. Hess of the U. S. Geological Survey and foreign consuls.
* Estimated.

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[1] *Min. Jour.*, July 13, 1918.
[2] *Comm. Rept.*, May 16, 1919.
[3] *So. Afr. Min. Jour.*, July 20, 1918.
[4] *So. Afr. Min. Jour.*, Feb. 22, 1919.

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URANIUM AND VANAIDUM

By Robert M. Keeney

Uranium

Because of the large production of radium for use in warfare more uranium ore was mined in 1918 than in any previous year. But it is doubtful if there was much increase in consumption of uranium, as its main outlet, ferro-uranium, did not apparently gain very much in favor with high-speed steel manufacturers. However, there probably was a slight increase in consumption of ferro-uranium over that of 1917.

Production.—As in previous years, the Standard Chemical Co. was the largest producer of carnotite ore, with smaller productions by the Radium Luminous Metals Corporation, the Schlesinger Radium Co., now called the Radium Co. of Colorado, the W. L. Cummings Chemical Co. and the Chemical Products Co. A production of about 100 tons of uranium ore was made from the newly discovered deposit of R. Lambert at Lusk, Wyoming. H. C. Meyer[1] estimates the production of carnotite for 1918 to be 8450 tons of ore averaging 2 per cent. U_3O_8 and 3.5 to 4 per cent. V_2O_5. This estimate seems low, because on a known production of not less than 20 grams of radium, 12,000 tons of 2 per cent. U_3O_8 carnotite ore would be required. The Standard Chemical Co.[2] owns about 350 claims in the carnotite district of Colorado. On these claims, the company stated[3] in 1918 that there was 6000 tons of ore certainly available for future operations.

Market.—The price of raw carnotite ore averaged for the year $2.50 per lb. of contained U_3O_8, but sold as high as $3 per pound. The price of U_3O_8 in the form of 90-per cent. uranium oxide ranged from $3 to $4 per lb. of contained U_3O_8. Standard ferro-uranium containing 35 to 50 per cent. uranium and 1.5 to 4 per cent. carbon sold at $7 per lb. of contained uranium. The Standard Alloys Co., a subsidiary of the Standard Chemical Co., was the only producer of ferro-uranium.

New Deposits.—The most notable discovery of uranium ore made in recent years was the deposit discovered at Lusk,[4] Wyo., in the spring of 1918. The deposit has proven itself by the production of several carloads

[1] *Eng. Min. Jour.*, Mar. 8, 1919, p. 453.
[2] "Radium Production." C. H. Viol, *Science*, Mar. 7, 1919, p. 227.
[3] "Radium Production." Dr. R. B. Moore, *Science*, 1919.
[4] "A New Depcait of Uranium Ore." Dr. S. C. Lind and C. W. Davis, *Science*, May 9, 1919, p. 441.

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of ore containing 3 per cent. U_3O_8. Lusk, Wyo., is on the Chicago and Northwestern Railroad, about 20 miles from the eastern boundary of Wyoming. Although considerable prospecting has been done in the region since the first discovery, the uranium ore so far appears to be confined to a single hill about one quarter of a mile in circumference at the base and tapering up to a sharp conical top about 350 ft. above the base. The uranium occurs entirely in quartzite which lies between mica schist and granite. The ore is marked by its extreme variations in appearance. The most typical variety is greenish-yellow, very intimately mixed with quartzite having well rounded grains resembling tapioca in structure and color. However, the predominance of other oxides can completely alter the color and appearance of the ore without the uranium content being affected. For example, a variety containing iron oxide has a rich chocolate brown color, and yet contains 12 to 25 per cent. U_3O_8 in some cases. Predominance of greenish shades is due to the presence of copper carbonates. Other specimens are black with a glossy luster, owing to a very intimate mixture of a small quantity of uraninite in the quartzite. In the absence of coloring by these oxides, the mineral approaches a canary yellow, resembling carnotite. In some cases, the colors are found absolutely different in a single piece of quartzite without the uranium content differing in the various parts of the piece. A very small proportion of uraninite can color the quartzite a jet black.

Optical measurements by Dr. E. D. Larsen of the United States Geological Survey indicate very decidedly that the mineral is identical with uranophane, a hydrated calcium silicate containing some barium and lead, to which the formula $CaO(UO_3)_2(SiO_2)_2.6H_2O$ has usually been assigned. It is readily soluble in acids. Microphotographs by Dr. F. B. Laney of the U. S. Bureau of Mines indicate that the uraninite in the quartzite was introduced subsequent to the deposition of the sandstone and replaced the cementing material and to a less extent the sand grains themselves. He believes the mineral is probably an oxidation product of uraninite, U_3O_8.

The chemical evidence of Dr. S. C. Lind and C. W. Davis of the U. S. Bureau of Mines, on 80-per cent. material, indicates that the soluble bases and acids account for each other without reference to the uranium oxide at all. This was taken to indicate the existence of a free higher oxide, probably UO_3. The occurrence of this oxide in nature would constitute a new mineral, but its occurrence must be confirmed by further examination.

A small quantity of uranium oxide was discovered in fluorspar being mined at Jimtown,[1] Colorado. The fluorspar as mined contained only

[1] "The Colorado Pitchblende Co." *Min. Sci. Press*, Mar. 29, 1919, p. 429.

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0.05 per cent. U_3O_8. Extensive plans for development and promises of great profits were so advertised in the local newspapers by the Colorado Pitchblende Co. that an investigation was made by local associations to protect the public, with the result that many local mining and metallurgical engineers decided that claim of large possible profits was unwarranted. It was planned to produce gold-silver-lead concentrate, fluorspar and uranium oxide. Operations are still being conducted.

Uranium ore was discovered in the State of Chihuahua, Mexico.[1] A pitchblende deposit containing ore having 26 per cent. U_3O_8 was reported[2] in Devonshire, England. Pitchblende was also discovered in small quantity in the Joe Reynolds mine located near Idaho Springs, Colo.

Mining.—Karl L. Kithel and John A. Davis describe the methods used in the mining and concentration of the carnotite ores treated in the plant of the National Radium Institute.[3] As the workable carnotite deposits of Colorado and Utah, though lying near the surface, are relatively small, vary greatly in richness and are very irregular in distribution, methods such as are ordinarily used for prospecting and mining shallow deposits must be modified. It is necessary to examine the ore carefully, sort it closely, and frequently test its radium content with the electroscope. The carnotite deposits are mostly in an arid region where water is scarce, so that dry rather than wet concentration must be used.

The prospecting and mining of carnotite deposits as practised by the Standard Chemical Co. is described by W. T. Roberts.[4]

The Standard Chemical Co. employs two methods of prospecting, both by means of drills. The first method employs the diamond core drill. A series of holes is planned, covering a given acreage, at intervals of 25 feet. If one of the holes indicates the presence of ore, another series is then drilled around it, sometimes only a few feet apart. With the diamond drill, holes 40 to 50 ft. in depth are commonly put in, this being the limit of occurrence of carnotite ore below the surface.

The rig most used is the Sullivan "Bravo" machine, operated by a belt from a gasoline engine. The drill, engine and pump for forcing water down the rods are mounted on heavy timbers with low wheels, so that moving from hole to hole is an easy matter. The great number of prospects and their shallowness makes this a handy arrangement. In this formation the rate of progress is perhaps 30 ft. per shift. The cost is low because of this high speed and because the wear of diamonds is

[1] *Eng. Min. Jour.*, July 13, 1918.
[2] *Can Chem. Jour.*, Feb., 1919.
[3] "Mining and Concentration of Carnotite Ores." Karl L. Kithel and John A. Davis, *Bull.* 103, U. S. Bureau of Mines.
[4] "Method of Prospecting Paradox Valley." W. T. Roberts, *Colo. School of Mines Mag.*, Feb., 1919, p. 40.

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slight. At first borts were used in the pits; later black diamonds or carbons were employed, such as are used in all hard mineral formations with these drills. While the initial cost is more, the cost per foot of drilling is much less. Substitutes and the diamond drill have been tried, but the combination described above has proven most economical. The drills are operated by a crew of two men with a general foreman in charge of several machines.

Another method of prospecting, still more widely used, employs Sullivan air-tube rotator hammer-drills, weighing 39 lb. each and operated by one man. These machines are used for the shallower holes, seldom exceeding 30 ft. in depth. They employ hollow drill steel in 2-ft. changes. A jet of live air, carried down the steel to the bits, acts to blow the cuttings to the surface in spite of such obstacles as clay seams, which are frequently encountered. The powerful rotation of the drill is a factor in enabling it to work successfully to such a depth. Light steel tripods are used to lift the longer lengths of steel. At intervals, or if trouble with dust arises, the steel is withdrawn and a blowpipe used to clean the hole. These Sullivan hammer-drills are operated by gasoline engine-driven air-compressors of the Sullivan WG-3 type.

The carnotite mines in a technical sense are seldom "mines" of much size or elaborateness, owing to the limited extent of the ore deposits. When a body has been sufficiently mapped out and when production is desired from it, a slope is driven and the mining is accomplished with the air-tube rotators described above. Mining is done in the ore under the sandstone strata, on a specialized room-and-pillar system. The slope is so driven that the tracks are lower than the mining floor. The ore is carried from the face in wheelbarrows and dumped from these into the cars. These cars are of small capacity, and are hauled up the slope by a windlass or a small air-hoist. They are then dumped onto a canvas or platform where the ore is sorted by hand. Little of the carnotite ore runs above 5 per cent. in grade. The value consists of uranium oxide, varying in grade from 0.5 to 7 per cent. Ore that must be milled is sent to a concentrator 12 miles from the company offices at Coke Ovens, and from 4 to 25 miles from the camps. Shipping ore, including that above 2.5 per cent., is sent to the company's works in Pennsylvania. All ore is placed in sacks of 100 lb. each, as it is sorted, owing to its great value.

Metallurgy.—The process used for the extraction of uranium and vanadium from the pitchblende of Joachimsthal, Bohemia, previous to the discovery of radium, is described in a paper by Gustave Gin,[1] now

[1] "Uranium: Its Extraction from Pitchblende." Gustave Gin, *Trans. Am. Electrochem. Soc.*, **35**, 1919.

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deceased. The uranium is obtained in the form of green oxide of uranium and vanadium as vanadic acid. A shorter process is used for extracting green oxide of uranium when vanadium is not present in appreciable quantity.

Gin describes the carbide method of extraction of uranium from pitchblende as developed by him:

The powdered mineral is roasted in a reverberatory furnace until sulphur is all removed. Almost all the arsenic is likewise removed and the uranium changed into sesquioxide.

The roasted material is mixed with carbon and put into an electric furnace with two hearths. The quantity of carbon introduced should be insufficient to reduce all the metallic oxides. The lead, copper, iron, nickel, cobalt, and perhaps a little of the tungsten, will be liberated as metals, and there is formed a slag containing silica and the lower oxides of uranium, vanadium, tungsten and molybdenum. The base metals are run off and carbon is then added to the slag in sufficient quantity to reduce all the oxides present and transform them into carbides.

The further treatment in the electric furnace gives a mass of carbides of uranium, tungsten, vanadium, and molybdenum, which if cooled quickly on removal from the furnace can be easily pulverized. The powdered carbides are treated with water at 60° C. Uranium carbide decomposes water, giving hydrated uranium oxide, green at first, but rapidly becoming blackish on contact with air. This precipitate is separated by flotation and dried and calcined. It then serves for the electric preparation of the pure metal or of its alloys or for the manufacture of uranium compounds such as the nitrate or alkaline salts.

The residue from the treatment with water contains all the unattackable carbides and silicides. It is dried and treated with potassium nitrate to fusion, resulting in a mixture of the alkaline vanadates, tungstates, molybdates and silicates. This fusion is dissolved in hot water and hydrochloric acid added. Tungstic and silicic acids are precipitated, while molybdenum and vanadium remain in solution with any phosphoric acid. After filtration and washing of the precipitate tungstic acid is separated from the silica by fusion with bisulphate of potassium. The product of this fusion is dissolved in water, which removes potassium sulphate and leaves a white residue of tungstic acid and silico-tungstate of potassium. The residue is treated with cold water to which is added ammonium carbonate, dissolving the tungstic acid and leaving the silico-tungstate undissolved.

In the solution coming from the first operation and containing molybdenum and vanadium it is extremely difficult to remove phosphoric acid, and it is preferable in practice to precipitate it as ammonium phospho-molybdate. The solution is concentrated and ammonia is added until a yellow precipitate is no longer formed. Filter, and in the filtrate the vanadium present may be precipitated as ammonium vanadate by adding ammonium carbonate and crystals of ammonium chloride. The filtered liquid contains only ammonium molybdate, that is if all the molybdenum has not previously passed into the phospho-molybdate. The ammonium molybdate is obtained by concentrating to dryness and calcined in the air to molybdic acid.

Finally molybdic acid may be separated from the phospho-molybdate by dissolving it in a concentrated ammoniacal solution and adding chloride of magnesium to precipitate the phosphoric acid as ammonium-magnesium phosphate.

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VANADIUM

There was a heavy production and consumption of vanadium during 1918. Toward the end of the year there was a considerable scarcity of ferrovanadium caused by the shortage of shipping available for importation of patronite from Peru, and perhaps, as rumored, by the decrease in actual production at the mines in Peru caused in turn by exhaustion of ore deposits. Exports[1] of ferrovanadium were 1,512,737 lb., as compared with 2,427,649 lb. in 1917, and 2,031,027 lb. in 1916. The signing of the armistice accounts in part for the decline in 1918, for the December, 1918, exports of ferrovanadium were only 51,073 lb. as against 291,520 lb. in December, 1917. Before the war these exports were very small, having been in 1913 only 604,287 lb. of ferrovanadium.

Production.—The production of ferrovanadium is estimated at 10,000,000 to 12,000,000 lb., or a vanadium content of 3,000,000 to 4,000,000 lb. The chief producers of ferrovanadium were the American Vanadium Co., the Primos Chemical Co., the Standard Chemical Co., the Goldschmidt Thermit Co., and the Electrometallurgical Co. A new producer was the Penn Electric Smelting Corp. The Radium Co. of Colorado, the Chemical Products Co., the Radium Luminous Metals Corporation and the Carnotite Reduction Co. all produced small quantities of iron vanadate as a by-product in radium extraction.

Peru continued to supply more than one-half the world's vanadium requirements, but the Peruvian production decreased considerably during the second half of 1918. In 1916, Peru[2] produced 3448 tons of vanadium ore which averaged 40 per cent. V_2O_5. The whole of the output was from the deposit owned by the American Vanadium Co. at Minasragra, and was exported to the United States. The total shipments from this mine since 1907 aggregate 18,787 tons, representing 7696 tons of oxides, 4323 tons of pure vanadium, or 85 per cent. of the world's output. The production from roscoelite deposits of Colorado probably remained about the same quantity as in 1917. The production of vanadium from carnotite increased considerably because of the large radium output. There was considerable activity in the development of vanadinite deposits. Early in 1919 the plant of the Primos Chemical Co. at Vanadium, Colo., was destroyed by fire. The plant was used for extraction of iron vanadate from roscoelite and is being re-built. The Colorado Vanadium Co. shipped ore from its properties at Sawpit, Colo., to the Primos Chemical Co., and in May, 1919, was producing 30 tons per day.

Market.—The market for ferrovanadium was strong during the whole year. The price increased from $3.25 early in 1918, to about $5.00 per

[1] *Iron Age.*
[2] *Iron Age*, Sept. 26, 1918.

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lb. of contained vanadium late in 1918. The price of iron vanadate, basis 35 per cent. V_2O_5, varied from 90 cts. per lb. to $1.20 per lb. of contained V_2O_5, delivered at New York. Vanadate of lead, basis 10 to 12 per cent. V_2O_5, no payment for other values, sold for from 70 cts. to 95 cts. per lb. of contained V_2O_5, delivered at New York.

Metallurgy.—Preliminary experiments on the extraction of vanadium, lead and copper from cuprodescloizite were made by J. E. Conley[1] of the United States Bureau of Mines. The ore tested was from the property of the Shattuck-Arizona Copper Co., Bisbee, Ariz. The mineral is found in a large vug as a deposit on brecciated quartz. At one time in 1915 the vanadium-bearing ore was exposed on the 600-ft. level for a length of 200 ft., average width 3 ft. and total height 600 ft. In this block there was estimated to be a tonnage of 3000 tons of ore averaging 10 per cent. V_2O_5, and in addition to this high-grade ore a large tonnage of ore containing from 1 to 1½ per cent. V_2O_5. The sample treated analyzed 8.06 per cent. V_2O_5, 7.31 CuO, 23.02 PbO, and 52.5 per cent. insoluble.

After a series of experiments it was decided that a combination of niter-cake fusion and sulphuric-acid leach was the most practical method of treatment.

This treatment consists of subjecting the ore to a preliminary fusion with niter cake followed by a hot-water leach, then treating the residue with sulphuric acid. It was found that by heating the ore with an equal weight of niter cake approximately two-thirds of the ore could be decomposed and the corresponding values extracted. The remaining values are then extracted by leaching the residue with about one-half as much acid as is required in the straight acid treatment. This procedure substitutes an amount of niter cake worth about two-thirds the value of the acid that would be required. This method would entail a slightly increased cost for labor and equipment, but the utilization of the cheaper chemicals would no doubt still render the use permissible from the standpoint of economy.

The ore should be mixed with the pulverized niter cake and heated barely to fusion. Sufficient water to break up the ore and to permit washing should be used, and boiling should not be continued any longer than necessary to accomplish this. In the experiments to determine the minimum amount of acid to treat the residue from the fusion, the residue was dried and divided into portions for the tests. In the working process the drying would be unnecessary, since the acid could be added directly to the moist residue.

[1] "Treatment of Cuprodescloizite for Extraction and Recovery of Vanadium, Lead and Copper." J. E. Conley, *Chem. Met. Eng.*, May 1, 1919, p. 465.

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The lead remaining in the residues was recovered as lead sulphate by sliming, with a recovery of 94.7 per cent. of the lead in the residues. Vanadium and copper were recovered from the solution by precipitation of the copper on scrap iron, followed by decantation, and addition of strong solution caustic soda until the solution gave a very slight acid reaction, and then boiling for 2 or 3 hours. The cement copper contained 95 per cent. copper and the iron vanadate 35 to 50 per cent. vanadium oxide. The total percentage extraction was as follows: vanadium 84 to 97 per cent., copper 85 to 98 per cent., and lead 82 to 89 per cent.

The conclusions drawn were as follows: (1) The recovery of the vanadium in cuprodescloizite by volatilization in a stream of chlorine or hydrochloric acid gas presents some interesting possibilities, but results obtained were unsatisfactory. (2) The vanadium in this mineral responds more readily to acids than to alkalies. (3) The straight sulphuric-acid leach gives quite satisfactory extractions and permits a good recovery. (4) The niter-cake fusion is undesirable alone, but is applicable as a preliminary treatment in a combined niter-cake-sulphuric acid process. (5) Copper or other metals undesirable in the iron vanadate must be removed to prevent contamination of the iron vanadate. (6) Boiling of precipitate after neutralization of acid solution is essential to obtain a good grade of iron vanadate. (7) A good grade of iron vanadate can be secured even in the presence of a large excess of iron if the neutralization is carefully controlled. (8) An ore, or concentrate, of the composition of the sample used can be economically treated and possibly at a cost less than the value of the by-products.

J. E. Conley[1] of the U. S. Bureau of Mines also investigated the extraction of lead and vanadium from vanadinite. The concentration of vanadinite is not a difficult process unless found with other very heavy minerals. The recovery of vanadium is quite satisfactory, provided an appreciable amount does not occur as the pentoxide. Very frequently vanadium minerals show a portion of the vanadium either as oxide or as compounds with calcium, copper, etc., and occur in the form of fine powder. In these cases the recovery in concentration is considerably lowered by the tendency of the powder toward sliming. The experiments made were only with view to treatment of vanadinite after concentration. Concentrates from a property near Ray Junction, Ariz., were treated. The concentrates contained: 53.88 per cent. PbO, 12.6 V_2O_5, 1.98 MoO_3, 4.26 Fe_2O_3, 1.21 Al_2O_3, 2.1 CaO, 16.93 per cent. insoluble. The concentrate was fused with soda ash, caustic soda and coal, resulting in the production of lead and a slag containing the vanadium.

[1] "A Proposed Metallurgical Process for the Treatment of Vanadinite for the Recovery of Lead and Vanadium," J. E. Conley, *Chem. Met. Eng.*, May 15, 1919, p. 514.

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The slag was leached with water to dissolve the vanadium. Slaked lime was added to the alkaline solution containing vanadium, molybdenum and other impurities to precipitate crude calcium vanadate, the impurities being discarded in the filtrate. The calcium vanadate was dissolved in cold sulphuric-acid solution, from which vanadium oxide was precipitated by boiling.

Results obtained by treatment of 50 lb. of ore were as follows:

Weight of ore, pounds	50.0
Weight of caustic soda, pounds	20.0
Weight of soda ash, pounds	5.0
Weight of coal, pounds	3.0
Weight of lead recovered, pounds	23.5
Percentage of lead recovered	93.2
Weight of slag recovered, pounds	42.0
Percentage of vanadium extracted	89.6
Percentage of vanadium recovered as calcium vanadate	89.6
Percentage of V_2O_5 in calcium vanadate after drying	13.64
Percentage of V_2O_5 in calcium vanadate after ignition	15.90
Percentage of V_2O_5 in final product	86.6

The actual amount of sulphuric acid consumed in dissolving the calcium vanadate was not determined on this run, since it is necessary to make a number of successive runs to determine the acid consumption. Tests were made, however, on smaller lots, and it was found that about 60 per cent. as much acid as calcium vanadate would be required. Assuming a 16-per cent. calcium vanadate, it would require about 4 lb. of 60° B. sulphuric for each pound of vanadium pentoxide, *i.e.*, for chemical alone it would cost only about 4 or 5 cts. per lb. of vanadium pentoxide.

The grade of the final vanadium pentoxide prepared by this treatment varies from 85 to 90 per cent. V_2O_5. The recovery is quite satisfactory, since it is maintained at the same level as the actual recovery of the vanadium from the slag. The only solution discarded, excepting as the volume of the solution after precipitation of V_2O_5 becomes too great, is the filtrate from the precipitation of the calcium vanadate. The actual acid consumption is large at the beginning of the cycle, since the excess of lime must be converted to sulphate along with the calcium vanadate; but when the calcium sulphate is used, very little acid is required to dissolve the calcium vanadate.

Exclusive of costs of mining and concentration, the cost of treatment of concentrate of the grade tested is estimated at $65 per ton, which leaves an ample margin of profit for commercial production at present prices for vanadium oxide.

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ZINC

By Jesse A. Zook

No better nor more comprehensive introduction to the situation in the zinc industry can be introduced than the following article from the *Engineering and Mining Journal* of Jan. 11, 1919:[1]

During the first quarter of 1918 curtailment of production was the order of the day. The full effects of this were seen in the second quarter. Thereafter, production was fairly steady, and although much less than in 1917 was large in comparison with the maximum pre-war year. In the latter part of 1918 the predominant feature was the pressure of the electrolytic producers, who made a steadily increasing output. The spelter producers had an unsold stock throughout 1918, and although it diminished in the second half there was considerable doubt whether metal was not simply passing from visible into invisible supply. The stock of spelter in hands of producers on Dec. 31 was 40,325 tons, compared with 60,415 tons at the beginning of the year.

The fundamentals in the zinc business of the United States are not encouraging. At the middle of 1918, after the weaker smelters had discontinued business, probably forever, there remained among the strong and active concerns capacity for producing 800,000 tons of spelter per annum, of which capacity they were able to use only about five-eighths. The capitalization of the idle capacity was estimated at $10,000,000. A similar situation existed with respect to mining and milling plants, of which the unused part was also estimated at $10,000,000. The direct cost of smelting in a large part of the plants had increased by something like 1¾ to 2 times, while the percentage of zinc extraction had diminished from an average of about 86 per cent to something like 82 per cent. The lot of the smelter was not therefore a happy one. The cost of mining had similarly increased in the Joplin district, but it was offset more or less by the mining of relatively rich ore in Oklahoma. The price of ore therefore declined relatively more than the price for spelter. Dissatisfaction over this condition led to a pooling arrangement being formed in October, but it was so uneconomic in its idea that it was bound to blow up, which, in fact, it did speedily. At the end of 1918 there was a large surplus of ore, which was salable only with difficulty, but the declining tendency in the spelter market indicated the approach of the day of curtailment both in mining and smelting, which would be the natural corrective.

American spelter producers have been looking for a revival of the export trade, but the prospect does not seem immediate. There was indeed a certain demand in November, which was met by the producers of high-grade metal. At about that time the British Munitions Ministry reported holding 18,769 long tons of common spelter and 6544 tons of high grade. France professed to have ample supplies. Indeed, the attitude of both the British and French governments was toward disposing of their holdings before letting any more foreign spelter in.

[1] The statistics, compiled by W. R. Ingalls, are those given as revised and complete in the later article, May 31, 1919.

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SPELTER PRODUCTION, 1913–1918, BY QUARTERS

(In Tons of 2000 Pounds)

Reports of Ore Smelters Only

District.	I.	II.	III.	IV.
1913.				
Illinois	27,924	28,523	26,118	28,966
Kansas-Missouri	22,006	23,820	19,204	20,127
Oklahoma	21,430	21,840	18,502	21,458
Others (a)	20,722	20,153	19,238	18,211
Totals	92,082	94,336	83,062	88,782
1914.				
Illinois	31,005	32,482	32,512	34,588
Kansas-Missouri	13,939	14,659	13,193	11,633
Oklahoma	22,563	22,960	22,945	23,999
Others (a)	22,717	22,715	24,106	24,296
Totals	90,224	92,816	92,756	94,516
1915.				
Illinois	35,786	39,511	41,791	44,577
Kansas-Missouri	14,090	24,554	32,152	40,256
Oklahoma	24,713	26,984	28,613	31,095
Others (a)	26,255	30,575	31,360	34,830
Totals	100,844	121,624	133,916	150,758
1916.				
Illinois	45,344	45,547	41,953	48,651
Arkansas	.....	.....	2,977	4,660
Kansas-Missouri	38,513	42,488	39,447	33,948
Oklahoma	34,994	38,786	42,604	52,680
Others (a)	37,853	39,873	41,514	48,186
Totals	156,704	166,694	168,495	188,125
1917.				
Illinois	48,756	47,237	40,379	39,699
Arkansas	5,597	6,847	7,596	5,661
Kansas-Missouri	26,350	25,621	19,443	15,091
Oklahoma	53,280	57,227	48,478	45,602
Electrolytic	7,950	8,362	5,096	5,837
Others (a)	42,013	41,700	39,736	38,853
Totals	183,946	186,994	160,728	150,743
1918.				
Illinois	34,848	34,829	36,445	35,686
Arkansas	6,156	5,603	7,618	7,373
Kansas-Missouri	10,284	5,016	7,198	9,336
Oklahoma	37,751	35,261	35,036	35,323
Electrolytic	8,094	9,407	11,049	10,335
Others (a)	36,881	36,265	35,481	34,075
Totals	134,014	126,381	132,827	132,128

(a) With the exception of one plant in Colorado these are all Eastern works. In the fourth quarter of 1915 and 1916 is included Anaconda and other electrolytic production.

PRODUCTION OF SPELTER

(In Tons of 2000 Lb.)

By Ore Smelters Only

States.	1913.	1914.	1915.	1916.	1917.	1918.
Arkansas	.....	.....	.....	7,637	25,701	26,750
Colorado	8,637	8 152	8,984	8,908	7,735	3,897
Illinois	111,551	130,587	161,665	181,495	176,071	141,808
Missouri-Kansas	85,157	53,424	111,052	154,396	86,505	31,834
Oklahoma	83,230	92,467	111,405	169,064	204,587	143,371
Electrolytic	.....	.....	.....	10,963	27,245	38,885
East and others (a)	69,687	85,682	114,036	147,555	154,567	138,805
Totals	358,262	370,312	507,142	680,018	682,411	525,350

(a) Includes Anaconda and other electrolytic production in 1915.

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Australia made an increased production of spelter in 1918, and Spain a decreased, but the output of those countries is small. During the first eight months Japan exported only about half the spelter it did in the corresponding period of the previous year. Whether this indicates diminished production, accumulation of stock, or both, we do not know. The production of British smelters in 1918 will be about 55,000 long tons. The great new smeltery at Avonmouth was not finished, nor were extensions to other plants, but these should be completed in 1919, and it is estimated that Great Britain's capacity for producing spelter at the end of 1919 will be 130,000 tons.

The electrolytic plant at Risdon, in Tasmania, is to be greatly increased in capacity, and new plants of considerable size are to be built in France (Pyrenees) and in Italy, but there is no expectation that any of these will be producers in 1919. Nor will be the new distillery of 25,000 tons' annual ore capacity of the Burma Mines, Ltd., at Sackchi, in India.

Recent reports to us from Belgium were that the smelting works of that country were not materially damaged, but it will be an indeterminate time before some of those along the Meuse can resume operations. However, some of the Belgian plants, including Overpelt and Lommel, in the Campine, were operated during the occupation.

The Dutch and French plants, except those in the coal fields of Northern France, are probably in a position to make their usual production as soon as they can be supplied with adequate ore and fuel. The smelteries of Rheinland and Westphalia are mainly within the zone of occupation. The zinc-mining and smelting district of Upper Silesia, near the Polish frontier, is now the scene of Polish advance, with consequential disorder.

The accompanying table gives the status of some things at quarterly intervals, the production figures being for the quarters terminating with the dates at the head of the respective columns.

	1917, Dec. 31.	1918.			
		Mar. 31.	June 30.	Sept. 30.	Dec. 31.
No. of smelters operating	26	24	24	24	24
No. of smelteries operated	38	34	31	32	32
No. of retorts in works operated	196,950	198,894	196,580	173,944	176,392
No. of retorts in use	127,193	124,072	110,956	118,008	124,068
Tons of distilled zinc produced	144,906	125,572	117,512	122,130	120,611
Tons of electrolytic zinc produced	5,837	8,096	9,404	11,124	10,568
Tons total zinc produced	150,743	133,668	126,916	133,254	131,179
Tons stock on hand	60,415	64,443	46,081	45,788	40,325

The production of spelter was maintained at a rather uniform rate, quarter by quarter, during the year. When the market was so sick in the early part of the year, and curtailment was the order of the day, production fell off sharply in the second quarter, but with the natural rally in the market producers mistook its meaning and light-heartedly increased their production to about the rate of the first quarter and maintained it during the fourth quarter, although nearly two months of the latter were after the armistice. The statistics make it evident that they

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overstayed their market, maintained their production when they ought to have been curtailing, and, in general, that they had either a misconception of the true state of affairs or were buoyed up by false hopes.[1]

ZINC-SMELTING CAPACITY OF THE UNITED STATES
(Number of Retorts at End of Years)

Name.	Situation.	1916.	1917.	1918.
American Spelter Co.	Pittsburg, Kan.	896	896	(h) 896
American Steel & Wire Co.	Donora, Penn.	9,120	9,120	9,120
American Zinc and Chem. Co.	Langeloth, Penn.	7,296	7,296	7,296
American Zinc Co. of Ill.	Hillsboro, Ill.	4,864	4,864	4,864
American Zinc, Lead and Smg. Co.	Dearing, Kan.	4,480	4,480	(g) .....
American Zinc, Lead and Smg. Co.	Caney, Kan.	6,080	6,080	(n) 6,080
American Zinc, Lead and Smg. Co. (c) (a)	Neodesha, Kan.	3,760	3,760	(g) .....
American Zinc, Lead and Smg. Co. (c)	E. St. Louis, Ill.	4,864	5,620	5,620
Arkansas Zinc, Lead and Smg. Corpn.	Van Buren, Ark.	2,400	3,200	3,200
Athletic Min. and Smelting Co.	Fort Smith, Ark.	(d)	1,664	2,496
Bartlesville Zinc Co.	Bartlesville, Okla.	7,488	5,184	7,488
Bartlesville Zinc Co.	Blackwell, Okla.	8,800	9,600	9,600
Bartlesville Zinc Co.	Collinsville, Okla.	13,440	13,440	(g) .....
Bartlesville Zinc Co., Lanyon-Starr Branch	Bartlesville, Okla.	3,456	3,456	3,456
Chanute Spelter Co. (a)	Chanute, Kan.	1,280	(g)	.....
Collinsville Zinc Co. (a)	Collinsville, Ill.	1,984	1,984	(h) 1,984
Eagle-Picher Lead Co.	Henryetta, Okla.	3,000	3,000	4,000
Edgar Zinc Co.	Carondelet, Mo.	2,000	1,982	(g) .....
Edgar Zinc Co.	Cherryvale, Kan.	4,800	5,040	5,040
Fort Smith Spelter Co.	Fort Smith, Ark.	2,560	2,560	2,560
Grasselli Chemical Co.	Clarksburg, W. Va.	5,760	5,760	5,760
Grasselli Chemical Co.	Meadowbrook, W. Va.	8,544	8,520	8,520
Grasselli Chemical Co.	Terre Haute, Ind.	(d)	3,360	4,200
Hegeler Zinc Co.	Danville, Ill.	5,400	5,400	5,400
Henryetta Spelter Co.	Henryetta, Okla.	3,000	(a) 3,000	(b) 3,000
Illinois Zinc Co.	Peru, Ill.	4,640	4,640	5,440
Iola Zinc Co.	Concreto, Kan.	660	(g)	.....
Joplin Ore and Spelter Co.	Pittsburg, Kan.	(f) 1,792	(g)	.....
J. B. Kirk Gas and Acid Co.	Iola, Kan.	3,440	3,440	(b) 3,440
Kusa Spelter Co.	Kusa, Okla.	3,720	7,520	5,360
La Harpe Spelter Co.	Kusa, Okla.	4,000	(k)	.....
Lanyon Smelting Co.	Pittsburg, Kan.	448	(h) 448	(h) 448
Robert Lanyon Zinc and Acid Co.	Hillsboro, Ill.	3,200	3,200	3,200
Lanyon-Starr Smelting Co. (e)	.....	.....	.....	.....
Mathiessen & Hegeler Zinc Co.	La Salle, Ill.	6,168	6,168	6,168
Mineral Point Zinc Co.	Depue, Ill.	9,068	9,068	9,068
Missouri Zinc Smelting Co.	Rich Hill, Mo.	(f) 448	(g)	.....
National Zinc Co.	Bartlesville, Okla.	4,970	4,256	4,160
National Zinc Co.	Springfield, Ill.	3,800	4,480	4,480
Nevada Smelting Co.	Nevada, Mo.	672	(g)	.....
New Jersey Zinc Co. of Penn.	Palmerton, Penn.	7,200	7,200	7,200
Oklahoma Spelter Co.	Kusa, Okla.	(f) 1,600	(h) 1,600	(h) 1,600
Owen Spelter Co.	Caney, Kan.	1,920	1,920	(h) 1,920
Pittsburg Zinc Co.	Pittsburg, Kan.	910	(h) 910	(h) 910
Prime Western Spelter Co. (o)	Iola, Kan.	4,866	4,866	1,972
Quinton Spelter Co.	Quinton, Okla.	1,340	2,016	2,016
Sandoval Zinc Co.	Sandoval, Ill.	672	672	672
Tulsa Fuel and Manufacturing Co.	Collinsville, Okla.	6,232	6,232	6,232
United States Smelting Co.	Altoona, Kan.	4,600	4,640	(g) .....
United States Smelting Co.	Checotah, Okla.	4,480	5,120	5,120
United States Smelting Co.	La Harpe, Kan.	1,926	(g)	.....
United States Zinc Co. (l)	Henryetta, Okla.	1,200	2,400	3,448
United States Zinc Co.	Sand Springs, Okla.	8,000	8,000	7,560
United States Zinc Co.	Pueblo, Colo.	1,984	2,200	2,200
United Zinc Smelting Corpn.	Moundsville, W. Va.	(d)	(m) 1,728	1,728
United Zinc Smelting Corpn (i)	Clarksburg, W. Va.	3,648	3,648	(a) 3,648
Weir Smelting Co.	Weir, Kan.	448	(a) 448	(h) 448
Totals	.....	212,614	216,046	189,026

(a) Closed during latter part of year. (b) No report received; entered the same as previous year. (c) Formerly Granby Mining and Smelting Co. (d) Under construction. (e) See Bartlesville Zinc Co. (g) Dismantled. (h) Idle all year. (i) Formerly Clarksburg Zinc Co. (j) Idle latter part of 1916. (k) Absorbed by Kusa Spelter Co. (l) Formerly Western Spelter Co. (m) Not yet in operation. (n) Part (4 blocks) leased to Weir Smelting Co. (o) Plant at Gas City, Kan., wrecked by cyclone, March, 1918.

[1] *Eng. Min. Jour.*, Jan. 25, 1919.

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The decrease in spelter production for the year was in the lower grades. As shown in the following table there was a large increase in the output of grade A. The decline in price of the different grades is also shown.

PRODUCTION AND STOCKS OF SPELTER BY GRADES, 1917–18
(Includes Redistilled Secondary Spelter)

Grade.	Production, Short Tons, 1917.	Price, Cents Per Pound, 1917.	Production, Short Tons, 1918.	Price, Cents Per Pound, 1918.
A	97,707	14.0	129,023	11.1
B	69,189	12.7	68,987	10.7
C	148,749	9.4	98,584	8.0
D	370,763	9.0	230,930	7.9
Total	686,408	10.2	527,524	9.1

The above tables and the following, showing apparent consumption of primary spelter, and imports and exports of zinc ore and products, were compiled by C. E. Siebenthal for the U. S. Geological Survey.

CONSUMPTION OF PRIMARY SPELTER IN THE UNITED STATES (a)
(Short Tons)

	1912.	1913.	1914.	1915.	1916.	1917.	1918.
Supply:							
Stock, Jan. 1:							
In bonded warehouses	32	48	.....	111	32	90	32
At smelters	9,049	1,474	40,659	19,984	14,221	17,508	53,689
Production:							
From domestic ore	323,907	337,252	343,418	458,135	563,451	584,597	492,405
From foreign ore	14,899	9,424	9,631	31,384	104,005	84,976	25,522
Imports	11,115	6,100	880	904	684	257	35
Total available	359,002	357,298	394,588	510,518	682,393	687,428	571,683
Withdrawn:							
Exports, foreign, from warehouse	6,286	6,027	5,580	12,776	43,230	64,680	20,069
Exports, foreign, under drawback	1,219	7,459	4,981	255	.....	1,588	3,255
Exports, domestic	6,634	7,783	64,807	118,603	163,137	153,796	80,244
Stock, Dec. 31:							
In bonded warehouses	48	.....	111	32	90	32	.....
At smelters	4,474	40,659	19,984	14,221	17,508	53,689	41,241
Total withdrawn	18,661	61,928	95,463	145,887	223,965	273,785	144,809
Apparent consumption	340,341	295,370	299,125	365,438	458,428	413,643	426,874

(a) C. E. Siebenthal, U. S. Geol. Surv.

EXPORTS OF DOMESTIC ZINC ORE AND DROSS

Zinc ore	23,349	17,713	11,110	832	70	1,179	55
Zinc dross	205	28	2,526	4,167	48	13,302	15,816

IMPORTS OF ZINC ORE AND ZINC DUST

Zinc ore	43,940	31,416	31,962	158,852	344,611	188,925	63,305
Zinc content	17,567	13,497	12,132	57,669	148,147	72,474	24,809
Zinc dust	.....	2,191	2,302	856	934	401	12

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SPELTER CLASSIFICATIONS, 1911–1918

	A.			B.				C.					D.			
	"High Grade" A.S.T.M., 1911. (a)	"High Grade No. 1" A.S.T.M., 1918. (b)	Navy, 1917. (c)	Army, 1918. (d)	"Intermediate" A.S.T.M., 1911. (a)	"Intermediate No. 2" A.S.T.M., 1917. (b)	Navy, 1917. (c)	Army, 1918. (d)	"Brass Special No. 3" A.S.T.M., 1917. (b)	"Brass Special" A.S.T.M., 1911. (a)	Navy, 1913. (e)	"Selected No. 4" A.S.T.M., 1917. (b)	Navy, 1917. (c)	Army, 1918. (d)	"Prime Western A.S.T.M., 1911. (a)	Navy, 1913. (e)	"Prime Western No. 5" A.S.T.M., 1917. (b)	"Prime Western" Metal Exchange, 1916. (f)
Zinc, minimum	0.05	0.07	99.85	99.50	.....	.....	99.35	99.35	.....	.....	98.60	.....	98.00	98.00	.....	98.00	.....	.....
Cadmium, maximum	0.03	0.03	0.05	0.50	0.50	0.50	0.50	0.50	0.50	0.75	0.75	0.75	0.75	0.75	.....	0.75	.....	.....
Iron, maximum	0.07	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.08	0.08	0.08	0.08	0.08	0.08
Lead, maximum	0.07	0.07	0.07	0.10	0.20	0.20	0.20	0.25	0.60	0.75	0.75	0.80	1.00	1.00	1.50	1.50	1.60	2.00
Cadmium, iron, lead, maximum sum	0.10	0.10	0.10	0.50	0.50	0.50	0.50	0.65	1.00	1.20	1.20	1.25	1.50	1.50	.....	2.00	.....	.....
Aluminium, maximum	.....	.....	.....	.....	.....	.....	Tr.	Tr.	.....	.....	Tr.	.....	Tr.	Tr.	.....	Tr.	.....	.....
Other elements	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Tr.	.....	Tr.	Tr.	.....	Tr.	.....	.....

(a) *Am. Soc. Test. Mat. Proc.*; vol. 11, pp. 147–149, 1911: Adopted August 21, 1911.
(b) *Am. Soc. Test. Mat. Proc.*; vol. 16, pp. 583–589, 1916; vol. 17, pp. 180–181, 1917.
(c) Navy Department Specifications, 47Zid, June 1, 1917.
(d) U. S. Army, Ordnance Department Specifications, Revised March 7, 1918.
(e) Navy Department Specifications, 47Zlb, Nov. 1, 1913.
(f) New York Metal Exchange Specifications; *American Metal Market*, August 31, 1916.

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Spelter Classifications.—The percentage composition of the various classifications adopted since 1911 are given in the accompanying table.

The Zinc Market in 1918[1]

At the beginning of 1918 common spelter was quoted at 7⅝ cts. St. Louis. There was an over-production and stocks were accumulating. The statistical conditions caused a decline in the market to 6.60 cts. That relatively low price, which was estimated to be equivalent to about 3¾ cts. before the war, caused a general closing of inefficient smelteries. Many of these were abandoned, and not a few were dismantled.

The curtailment of production was overdone, in view of the continued large requirement of spelter for brass making, and the market price rallied to about 8½ cts. at the beginning of July. After a minor setback, further improvement in the statistical position advanced the price to 9⅜ cts. in September, but with this advance the margin between common and high-grade spelters contracted, and eventually it ceased to be profitable to refine by redistillation. The supply of common spelter for sale being thus increased, the market started on a slow but steady decline. The advent of the armistice did not produce in zinc just the same conditions as in copper and lead, for zinc had never been under control. However, the weakness of the market became a little more pronounced, and 1918 closed with the quotation of 7.45 cts.

At the beginning of 1918 high-grade spelter was quoted in the neighborhood of 12½ cts. During the spring the War Industries Board fixed 12 cts. as a maximum price. A little later, an alteration in the Army specifications increased the supply of high-grade metal. The market becoming more competitive, the price declined below 12 cts. Toward the close of 1918 high-grade metal was sold at 9 cts. and at the very end of the year it is doubtful if it were properly quotable above 8½ cts.

The prices of sheet zinc and rolled plate were fixed at 15 and 14 cts. respectively, and those prices were maintained until the end of 1918, the supply being steadily short, because of insufficient manufacturing capacity. Owing to the large profit that those prices permitted, the producers of special grades of ore in the Joplin district claimed a participation in it and obtained a fixed price of $75 per ton, the requirements of the sheet-zinc producers being prorated among those ore producers.

[1] W. R. Ingalls. *Eng. Min. Jour.*, Jan. 12 and May 31, 1919.

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MONTHLY AVERAGE PRICE OF SPELTER

Month.	New York.			St. Louis.			London.		
	1916.	1917.	1918.	1916.	1917.	1918.	1916.	1917.	1918.
Jan.	16.915	9.619	7.836	16.745	9.449	7.661	89.810	48.329	54.000
Feb.	18.420	10.045	7.814	18.260	9.875	7.639	97.762	47.000	54.000
Mar.	16.846	10.300	7.461	16.676	10.130	7.286	95.048	47.000	54.000
Apr.	16.695	9.459	6.890	16.525	9.289	6.715	99.056	54.632	54.000
May	14.276	9.362	7.314	14.106	9.192	7.114	94.217	54.000	54.000
June	11.752	9.371	8.021	11.582	9.201	7.791	68.591	54.000	54.000
July	8.925	8.643	8.688	8.755	8.473	8.338	50.750	54.000	54.000
Aug.	8.730	8.360	8.985	8.560	8.190	8.635	51.587	54.000	54.000
Sept.	8.990	8.136	9.442	8.820	7.966	9.092	52.095	54.000	54.000
Oct.	8.829	7.983	8.801	9.659	7.813	8.451	54.159	54.000	54.000
Nov.	11.592	7.847	8.491	11.422	7.672	8.141	56.023	54.000	54.100
Dec.	10.665	7.685	9.163	10.495	7.510	7.813	55.842	54.000	56.050
Year.	12.804	8.901	8.159	12.634	8.730	7.890	72.071	52.413	54.180

New York and St. Louis, cents per pound. London, pounds sterling per long ton.

AVERAGE PRICE OF ZINC SHEETS
(In Cents per Pound)

	1916.	1917.	1918.		1916.	1917.	1918.		1916.	1917.	1918.
Jan.	23.40	21.00	19.00	May	24.00	19.00	15.00	Sept.	15.00	19.00	15.00
Feb.	24.50	21.00	18.00	June	19.50	19.00	15.00	Oct.	[1]5.20	19.00	15.00
Mar.	25.00	21.00	15.00	July	15.60	19.00	15.00	Nov.	18.25	19.00	15.00
April	25.20	20.44	15.00	Aug.	15.00	19.00	15.00	Dec.	21.00	19.00	15.00

Average for the year 1915—17.37 cents, 1916—20.14 cents, 1917—19.62 cents, 1918—15.58 cents.
NOTE.—These are base prices for ordinary size sheets, in carload lots, f.o.b. LaSalle-Peru, Ill., less 8 per cent. discount.

IMPORTS

ZINC ORE IMPORTED INTO THE UNITED STATES, 1915-1918, IN SHORT TONS

Source.	1915.		1916.		1917.		1918.	
	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.
Canada	4,710	$177,868	8,790	$567,259	5,155	$338,668	5,173	$319,815
Mexico	17,804	2,130,014	51,028	5,779,564	45,697	2,837,211	18,426	1,202,035
France	.....	.....	1,422	56,542	.....	.....	.....	.....
Spain	.....	.....	23,081	1,550,334	6,084	260,992	.....	.....
Italy	2,125	153,388	5,783	394,782	2,411	117,271	.....	.....
French Africa	.....	.....	1,857	129,153	.....	.....	.....	.....
French East Indies	.....	.....	746	55,407	.....	.....	.....	.....
China and Hongkong	2,738	119,913	4,568	344,192	.....	.....	.....	.....
Japan	499	77,899	.....	.....	.....	.....	.....	.....
Australia	29,723	1,843,801	49,748	3,117,304	12,503	753,598	.....	.....
New Zealand	.....	.....	944	105,880	.....	.....	.....	.....
Other countries	69	7,663	271	20,968	625	66,388	1,210	52,119
	57,669	$4,510,546	148,147	$12,121,385	72,474	$4,374,058	24,809	$1,573,969

ZINC MINING IN THE UNITED STATES

Arizona.[1]—The output of recoverable zinc decreased from 20,894,860 lb. in 1917 to only 2,269,643 lb. in 1918. The value decreased from over $2,000,000 to about $206,500. The Golconda mine, in the Wallapai district, Mohave County, formerly a large producer, was closed, and the

[1] U. S. Geol. Surv.

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Tennessee mine, which produced lead-zinc milling ore, was practically worked out and sold to the Schuylkill Mining Co., which owns adjoining ground. Considerable zinc shipments came from the Duquesne property, in Santa Cruz County, and from the Hillside property, in Yavapai County.

California.[1]—The recoverable zinc output of the State in 1918 was 5,561,393 lb., valued at $506,088, compared with 10,872,716 lb., valued at $1,109,017 in 1917, which is a falling off in quantity of 5,311,323 lb. and in value $602,929. The direct reports from the few large properties producing zinc in Shasta and Inyo counties show that their outputs were very much restricted in 1918, their attention being directed to more profitable metals in their ores. The only large electrolytic plant in the State has been closed down.

Colorado.[1]—Although Leadville, Colo., has been one of the most important mining centers in the country for the last 40 years and during that time has produced oxidized ores of gold, silver, and lead, as well as sulphide ores of these metals and of zinc and copper, it was not until 1910 that oxidized zinc ore was discovered there in commercial quantity. The discoverers of this ore found that the engineers who had run the old shafts and drifts had driven them through large masses of it without suspecting its character, and the engineers and geologists who had frequently examined the mines as well as the managers and superintendents who had been in the workings almost daily made some rather amusing excuses to account for their lack of perception. All, however, had to share the blame for having overlooked the ore.

More than 140,000 tons of oxidized zinc ore, containing an average of 29 per cent. of zinc, was mined at Leadville in 1912. Since that year both the quantity and the tenor of the ore mined have decreased. The bodies of high-grade ore that furnished the large shipments from Carbonate Hill have been worked out, and the other bodies of equally high-grade ore that have been exploited are much smaller. Extensive bodies of low-grade ore containing from 15 to 23 per cent. of zinc are now being worked and will continue to furnish a considerable supply of ore for many years if the demand continues.

The oxidized zinc ores of Leadville are discussed in *Bulletin* 681 of the United States Geological Survey, by G. F. Loughlin, who describes the several varieties of ore and their component minerals, as well as the distribution, mode of occurrence, and origin of the ore, and makes suggestions to prospectors for orebodies.

The output of the State in 1918 was 86,550,000 lb., compared with 114,000,000 lb. in 1917. The decrease in value amounted to $10,000,000.

[1] U. S. Geol. Surv.

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Idaho.—The zinc industry of Idaho suffered a serious setback during 1918, due to slack market conditions for the mineral. The Interstate Callahan mine, in the Coeur d'Alene district, continued to be the principal source of zinc ore shipments in the State. The stopes of this mine were idle 7 months of the year, but development increased the ore reserves in the lower levels, which maintain their quality of high-grade zinc sulphide ores. The large tailing pile was retreated with excellent recoveries. In the same vicinity the Success mine was reopened and a number of shipments of zinc and lead concentrates made. The disclosure of a dike of diabase with a strong band of rich zinc-lead ore on each contact bears on the persistency and expansion of the ore channel at further depth.

An interesting deposit of clean gray zinc sulphide ore in a white quartz vein was developed at the Azurite mine and equipped with a small jigging plant, producing two carloads of 60-per cent. zinc concentrates during the year. This mine is near Ballards landing, just north of the Iron Dyke copper bonanza on the Idaho side of Snake River canyon, near Homestead, Oregon. The vein varies from one to 4 ft. wide with 5 to 10 per cent. zinc values. It is developed 500 ft. long by adit tunnels and traceable at the surface 2000 ft. The Drilling Development Co. in Lemhi County, 12 miles east of Solomon City, has a promising shallow deposit of zinc. It is ideally situated for open-work mining or quarrying on a very steep slope of the main range of the Rocky Mountains, made up of pre-Cambrian sediments of silicious shales, slates and quartzites.[1]

The state inspector reports an output of 51,601,000 lb. of gross metal contents of zinc, a decrease of about 28,000,000 lb. from 1917. One of the main decreases was made by the largest zinc producer in the State, the Consolidated Interstate Callahan, which was treating a large tonnage of accumulated tailings during the third quarter of the year, while development was progressing in the mine. The Success mine, which was formerly a large zinc producer, shipped only about one-fourth of its former output. Other zinc shipments were made from the Morning, Frisco, Hercules, and Hecla. The Douglas property, on Pine Creek, was not as productive as formerly on account of difficulty in transporting the ore, and the Surprise Consolidated, in the same district, was idle. Considerable shipments of zinc ore came from the Amazon-Manhattan, adjoining the Interstate Callahan, and in Blaine County shipments were made from the North Star and the Kusa property.

Montana.[2]—The output of recoverable zinc in Montana increased from 186,259,331 lb. in 1917 to 209,258,148 lb. in 1918. The value

[1] Excerpt from report of Robert N. Bell, State Inspector of Mines.
[2] U. S. Geol. Surv.

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of the output increased from $18,998,452 to $19,551,000. The three main zinc producers of Montana were the Butte and Superior, the Anaconda mines, and the Elm Orlu property. Other noteworthy producers were the Snow Storm mine, in Lincoln County; the Davis Daly, at Butte; and the Emma mine of the Butte Copper and Zinc Co. Many of the Western States showed decreases in zinc production in 1918, but Montana produced an unusually large quantity on account of the activity of the plant at Great Falls, which was making about 6,000,000 pounds of spelter a month.

Nevada.[1]—The mine output of recoverable zinc decreased from 22,307,868 lb. in 1917 to only 16,724,753 lb. in 1918. The value of the output decreased from $2,275,402 to about $1,522,000. Nearly all of the output came from the Yellow Pine district of Clark County, though there was a distinct decrease from this region. The Consolidated Copper mines, in White Pine County, made large shipments of zinc ore, as did the Combined Metals Co., at Pioche.

New Mexico.[2]—Decreased shipments of zinc carbonate and zinc sulphide ores were made in 1918. At Kelly, Socorro County, the principal producing mines were the Kelly, Graphic, and Juanita. The Ozark mill was operated steadily, but the Kelly mill was not in operation. At Hanover zinc carbonate ores were shipped from the Empire zinc mines and others, and zinc sulphide concentrates were shipped from the Hanover magnetic separation mill. The Cleveland magnetic separation mill, at Pinos Altos, was operated steadily, but at a reduced yield. In September the Carlisle mill, in the Steeplerock district, Grant County, was again set in operation, and the lead concentrates were shipped, but the zinc concentrates were stored. Sulphide ores in considerable quantities were shipped from the Republic mine, at Hanover, and several lots of zinc sulphide concentrates were shipped from the Rocky Mountain mill, at Cerrillos. Zinc carbonate ores were shipped from the Magdalena, Hanover, and Cook's Peak districts. The zinc ore and concentrates shipped from mines in 1918 amounted to 45,982 tons of 33-per cent. grade, compared with 61,522 tons of 31 per cent. in 1917. The Grubnau zinc-oxide plant, built in 1917 at Waldo, Santa Fe County, was operated continuously on zinc ores from Arizona, New Mexico, and Colorado.

Oklahoma-Kansas.[3]—The Miami district includes the following camps: Commerce, Tar River, Century, Picher, Quapaw, Lincolnville, St. Louis, and Hockerville (all in Oklahoma); and Treece and Monarch (in Kansas, and for a distance of 2 miles north of the Oklahoma line into Kansas, and 6 miles east to Baxter Springs). The area is about 12 by 6

[1] U. S. Geol. Surv.
[2] U. S. Geol. Surv.
[3] A. E. Bendelaria, *Eng. Min. Jour.*, Jan. 18, 1919.

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miles, and it now contains over 150 concentrating plants, varying in capacity from 150 to 700 tons per 10-hour day. In the newer fields a number of prospecting drill rigs are in operation.

All this activity has arisen during the last 4 years. In fact, it is just 3 years since the first mills were built in Picher and Tar River. The pioneer operators had to go back and forth as best they could through mud that was almost impassable, and machinery had to be hauled across the prairies, but now these mines are served by two railroads, and an interurban system gives the town of Picher, which is the hub of the district, a half-hourly service to Joplin.

During the year 1918, the total production of zinc concentrates from the Oklahoma-Kansas district was 523,514,000 lb., valued at $13,974,906, and 99,146,000 lb. of lead concentrates, valued at $4,595,500; making a total of $18,570,406, which is a wonderful showing, considering the time the field has been in operation.

The total represents the output of many individual operations; however, the greater portion of the production was made by the larger companies whose names are given in the table.

LARGE OPERATING COMPANIES IN THE MIAMI DISTRICT

	Mills.
Commerce Mining and Royalty Co.	8
Eagle-Picher Lead Co.	8
Skelton Mining Co.	6
Admiralty Zinc Co.	6
Golden Rod M. & S. Co.	6
The Lucky Companies	5
Bilhars Mining Co.	4
Underwriters' Land Co.	3
The U. S. Smelting Co.	3
St. Louis S. & R. Co.	2
Anna Beaver Mining Co.	2

The price of the average grades of zinc ore for the year was unsatisfactory to the operators, whose production was based on war-time costs of labor and supplies. The price varied from $40, which was the bottom reached several times during 1918, to $57.50 per ton.

The producers of high-grade zinc ore, which carried less than 0.20 per cent. lead, were more fortunate, and, through an agreement with the zinc smelters who make sheets, and with the approval of Washington, enjoyed a price of $75 per ton for the larger part of the year. Many producers were able to make part of their production high-grade, and received a weekly allocation, which helped the average selling price. In other cases, those who were not able to make the high-grade had a good percentage of lead, and were able to get the benefit of the high lead price. In this way they brought up the average selling price for their concentrates.

Reference made to Kansas relates to the new field adjacent to the

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Oklahoma line, the western end of which is 3 miles west of Picher. There are now about 15 mills in this vicinity, and, although the field is new, the orebodies already opened up seem to be especially rich and have indications of being extensive.

Farther east, toward Baxter Springs, the Chanute Spelter Co., a subsidiary of the American Metal Co., has a large acreage under lease, and a number of prospecting drills in operation. The finding of a number of extensive orebodies is reported, and one mill is already built, and, when the shafts are completed, will begin operation. Heavy water flows have delayed the work, but three Pomona pumps operating in 16-in. drill holes are now draining the ground.

In pre-war times the cost of mining and milling a ton of rock in the old Joplin-Webb City district was figured roughly at $1. For the last 3 years this has increased gradually, until there are few companies at present in either the Joplin or the Oklahoma-Kansas field which can produce for less than $2, and the average is probably higher. This has worked a great hardship on the old district, where the recoveries were small, and a number of mills that made the Joplin and Webb City district famous have been moved to Oklahoma, where the orebodies are richer.

As this district reached the producing stage since the beginning of the war, in 1914, one can but forecast its future when conditions become normal. With such demonstrated ore deposits as the district possesses, especially in the deeper levels, where they are very uniform, there can be no doubt, on account of the large mineralized area, that it will continue to be a heavy producer for years.

Utah.[1]—A relatively small amount of zinc ore was produced in Utah in 1918, chiefly by the largest mines, the miscellaneous production from the various camps being light. The chief producers of zinc sulphides, mostly concentrates, were the Judge Mining and Smelting Co., at Park City, which treated its output in its electrolytic zinc plant, producing a high-grade spelter, and the U. S. Mining Co., at Bingham, which shipped a good tonnage of lead-zinc ores to its Midvale concentrator during the first 10 months of 1918, and produced several hundred tons of zinc-blende concentrates per month from material treated by the Huff electrostatic plant. Later, the company stored its output. The Utah Apex produced zinc sulphide ores and concentrates. The Midvale Minerals operated its 250-ton flotation tailings plant on the old United States concentrator dumps, and shipped lead-zinc concentrates to Anaconda. The Childers and Leasing Co. also made a production from a different part of the same tailings dump. The Caldo Mining Co., operating a flotation mill on

[1] E. R. Zalinski, *Eng. Min. Jour.*, Jan. 25, 1919.

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the old Horn Silver dump at Frisco, Beaver County, made zinc concentrates running 43 per cent. and better, which were shipped East, and lead concentrates were shipped to the U. S. Smelting Co. The extraction was unusually good for an old dump of this character, being 68 per cent. and upward for the zinc, and 12 to 20 per cent. for the lead. Most of the lead had oxidized to anglesite.

Carbonate zinc ores were shipped by the Lake View Mining property, in Boxelder County, and the Scranton, in North Tintic; an occasional car of zinc ore was shipped by other mines in Tintic. A few cars were shipped by D. W. Lynch from Dry Canyon, near Ophir, but no zinc ore was produced in 1918 in Ophir itself. The Moscow, in Beaver County, shipped a few cars of ore mined in 1917. More zinc ores could easily have been produced with more moderate freight rates and lower operating costs.

The Judge Mining and Smelting Co. did some new development work in the southwestern part of the property under Bonanza Flat, and opened good ore there and in other parts of the mine. At the company's zinc plant, changes and additions were made, preparatory to starting the second unit about Jan. 1, 1919. The first section operated throughout 1918 and produced premium spelter exclusively, the product assaying 99.9 per cent. zinc or above in purity. With two units working, this plant will handle about 50 tons of zinc concentrates daily, as compared with a former production of 30 tons. By treating 45 tons of concentrates, the output will be around 15 tons of spelter daily, according to the grade of ore. The tonnage of silver, lead, and zinc ore mined by the Judge was approximately the same as in 1917.

The mine output of the State decreased from 21,286,871 lb. in 1917 to 18,399,417 lb. in 1918, and the value of the output from $2,171,261 to $1,674,000.

Washington.[1]—Washington mines produced only 38,873 lb. of recoverable zinc during the year, although in 1917 they produced 1,195,567 lb. of zinc. The Lead Zinc property, at Metaline Falls, a considerable producer in former years, was in financial difficulties, and the mine was closed. It was reported that the Bruce Creek Mining Co., northeast of Colville, had opened a body of zinc ore in November.

Wisconsin.[2]—The net tonnage of zinc ore shipped to smelters from the Wisconsin district in 1918 decreased 18 per cent. from that of 1917, as indicated in the accompanying table. The gross tonnage shipped from mines to smelters and to separating plants decreased 24 per cent.

A total of 58 mills and 7 separating plants were in operation during

[1] U. S. Geol. Surv.
[2] J. E. Kennedy. *Eng. Min. Jour.*, Jan. 11, 1919.

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1918, as against 68 mills and 9 separating plants in 1917. Seven concentrating mills were built new or moved and reconstructed, viz.: Lucky Six No. 2 (Linden), Connecting Link and Little Dick (Cuba City), Little Platte (Platteville), Dale Rundell (Livingston), Blewett (Galena), and Copeland (Shullsburg). At the close of 1918 the Zinc Hill Mining Co. was constructing a mill on the Harvey lease, Cuba City, and the Connecting Link Mining Co. was assembling material for another mill on the Coulthard tract, at Cuba City. At the year-end, W. W. Bonson, at Galena, was developing a separating process to extract the zinc content from roasted zinc tailings. The National Zinc Ore Separating Co. replaced its four Mathey roasting kilns with a multiple-hearth roaster of the Wedge type, having a capacity of 250 tons of raw ore in 24 hours. About July 15 the Government began the construction of two acid plants for the manufacture of 20 per cent. oleum. One, of 50 tons daily capacity, at the Skinner roaster of the Wisconsin Zinc Co., was 50 per cent. completed, and the other, of 100 tons capacity, at the National Separating plant, was 80 per cent. completed, when, in November, construction was ordered discontinued.

WISCONSIN ZINC-ORE SHIPMENTS
(Short Tons)

	Net to Smelteries, Tons.			Gross from Mines, Tons.		
	1916.	1917.	1918.	1916.	1917.	1918.
Highland	3,678	4,868	7,659	3,831	4,868	7,659
Linden	3,118	1,454	76	13,384	16,774	5,483
Mifflin	4,692	3,170	1,242	28,111	40,237	29,910
Mineral Point	27,013	35,075	34,429	728	958	368
Montfort	1,587	689	.....	1,836	971	.....
Platteville	4,560	4,953	2,781	14,832	8,301	3,203
Dodgeville	421	522	260	496	1,660	1,651
Cuba City	19,691	23,881	20,523	3,946	893	1,840
Benton-New Diggings	38,261	64,582	48,123	85,407	128,047	102,747
Hazel Green	1,312	614	.....	18,640	11,868	6,070
Shullsburg	704	5,227	3,355	7,629	11,674	11,646
Potosi	834	1,978	.....	834	2,812	164
Galena (Ill.)	12,662	1,753	405	15,732	18,930	13,094
Dubuque (Iowa)	53	.....	.....	53	.....	.....
Totals	118,586	148,766	118,853(a)	195,459	247,993	183,835(a)

(a) Totals to Dec. 14, 1918.

Mining operations were seriously handicapped by shortage of labor up to the middle of December. The level of wages advanced over the high mark of the previous year. Experienced shovelers, at 10 @ 12 cts. per can, under normal conditions, averaged $5 @ $6 per day. Underground drill men were paid $4 @ $6 per day wage and made as high as $8 on contract scale. Trammers generally received $3.50 @ $3.60 per day wage, hoister-men $4, grizzly-men $3 @ $3.50, crusher feeders $2.75 @ $3, and mill men $100 @ $150 per month.

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Comparatively little prospecting was carried on throughout 1918. Shortage of labor was somewhat offset by the installation of more power shovels of the Thew and Keystone types. The year's production record was held by the Hoskins, the youngest producer of the Mineral Point Zinc Co.'s group, which made a shipment total of 15,371 tons of blende, reported to Dec. 14. The Champion mine, of the Wisconsin Zinc Co., and the Yewdall mine, of the Vinegar Hill Zinc Co., were close behind.

The Joplin District.[1]—At the end of 1918 there were 30 mills in operation part time in the older mining areas of Jasper County, but at the end of May, 1919, a half dozen would embrace all in operation, with perhaps a dozen not removed. New developments in the Waco area cover the mining activity of Jasper County, the largest blende-producing county in Missouri. Ottawa County, Okla., has succeeded to first rank, with Cherokee County, Kansas, occupying second place. Even in the new fields of these two counties mining is not actively pushed owing to the inactivity of metal. The temporary improvement in metal conditions during the latter part of 1918 set in motion mining operations that caused an increased production of blende. Lower ore prices early in the year closed most of the mines producing calamine; these were not reopened, leaving a marked decrease in the production of this mineral. This decrease was largely in Newton County, Missouri, the heaviest calamine-producing section.

Flotation practice made rapid strides during 1918, accomplishing astonishing results for those installing it as an experiment, and establishing it as a fixed and approved method for the concentration of fines.

ORE PRICES IN JOPLIN DISTRICT
(Per Short Ton)

Year.	Zinc Ore.	
	High.	Average.
1904	$53.00	$35.92
1905	60.00	44.88
1906	54.00	43.30
1907	53.50	43.68
1908	47.00	34.36
1909	55.00	41.08
1910	52.00	40.42
1911	51.00	39.90
1912	67.00	53.33
1913	59.00	42.26
1914	54.00	40.46
1915	138.90	79.30
1916	131.70	84.72
1917	101.95	67.70
1918	78.70	51.33

[1] Jesse A. Zook, statistician, Joplin, Mo.

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MONTHLY AVERAGE PRICES OF BLENDE AND CALAMINE, IN 1918, IN THE JOPLIN DISTRICT

(Per Ton of 2000 Lb.)

	Blende.	Calamine.	All Zinc Ores.
January	$56.01	$35.97	$55.14
February	55.84	37.46	54.99
March	54.40	38.08	53.72
April	47.56	32.82	46.96
May	44.59	31.89	44.16
June	49.61	34.53	48.78
July	52.52	35.66	51.89
August	55.75	36.66	54.83
September	53.26	37.91	52.73
October	53.80	37.91	52.95
November	53.29	39.62	51.97
December	44.16	36.00	44.00
Year	$52.00	$37.14	$51.33

JOPLIN DISTRICT ORE SHIPMENTS, IN POUNDS, 1918

	Blende.	Calamine.	Lead.	Values.
Missouri:				
Jasper County	174,819,940	9,143,040	36,550,840	$6,464,650
Newton County	22,060,460	25,874,490	612,140	1,070,150
Lawrence County	3,060,860	4,868,360	249,280	171,660
Greene County	524,010	83,300	66,700	17,490
Christian County	231,040	165,510	.....	8,110
Howell County	.....	210,280	.....	2,380
Dade County	.....	115,880	.....	1,630
Barry County	34,270	59,390	.....	1,230
Totals	200,730,580	40,520,250	37,478,960	$7,743,300
Oklahoma:				
Ottawa County	632,149,430	.....	99,960,230	$20,838,000
Kansas:				
Cherokee County	101,604,140	.....	11,703,620	3,248,300
Arkansas(a)	200,980	3,697,090	81,730	75,650
District total, 1918	934,685,130	44,217,340	149,224,540	$31,905,250
District total, 1917	884,326,450	75,564,480	144,392,770	41,126,610
Increase	50,358,680	.....	4,831,770	.....
Decrease	.....	31,347,140	.....	9,221,360

(a) Ores settled for by Joplin purchasing agencies. An estimate of Mr. Dunlop, of the U. S. Geological Survey, places the total Arkansas production at 5000 tons of blende and calamine, and 200 tons of lead.

Foreign Zinc Smelting

In replying to an inquiry from a correspondent Mr. W. R. Ingalls published the following statement concerning the condition of foreign smelting in the *Engineering and Mining Journal*, Feb. 1, 1919:

Germany.—The largest production on record was in 1913, when Rheinland-Westphalia produced 92,852 metric tons, and Upper Silesia 170,119. Probably the smelting capacity was more or less in excess of those figures. The Rhenish-Westphalian smelters depended on Australian ore to a considerable extent. The Silesian smelters received some Australian ore, but in the main depended upon the local ore deposits, which are extensive.

Belgium.—Maximum production, 200,198 metric tons (in 1912), entirely dependent on imported ore. Some of the Belgian smelteries, especially those in the Campine, were operated during the war. With regard to the others, especially those in the

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valley of the Meuse, the information is that the damage is not much, but that it will be an indeterminate time before smelting can be resumed.

Holland.—Maximum production, 24,323 tons (in 1913). Operations continued during the war.

Great Britain.—According to my recent advices, smelting capacity at the end of 1918 is sufficient to make 55,000 tons of spelter per annum. With the completion of the new plants now being erected, it is expected that the smelting capacity at the end of 1919 will be 130,000 tons.

France.—Pre-war production was about 60,000 tons per annum. Some of the French plants, especially St. Amand and Auby, are situated in the north, and, being right in the zone of entrenchments, it is not improbable that they have been destroyed. The important works at Mortagne, near Givet, were in the zone of occupation, but, being German owned, they were not damaged. The chief smelteries of France, viz., Noyelles-Godault and Viviez, were out of danger and presumably were in regular operation. It is not unlikely that the French will now take steps to increase their zinc-smelting capacity. Indeed, plans are already being drawn for an electrolytic plant to make about 10,000 tons of spelter per annum in the Pyrenees, but production from that source is not to be expected until 1920 is well along.

Austria.—There are a few zinc smelteries in Austria, but their capacity is small. Nothing is known about their present situation.

Italy.—The Societa di Monteponi has a smeltery at Vado Ligure, but its production is small. However, a considerable production of electrolytic spelter is to be expected in Italy in the course of time. It is understood that plans are already being made for an electrolytic plant to be erected at Vallauria (San Dalmazzo di Tenda) by the Societa Anonima Elettromineraria of Savona. Other interests are making studies.

Poland.—Three small plants near the Silesian border have a capacity of producing about 10,000 tons per annum. There is no information respecting their present condition.

Norway and Sweden.—Several plants engaged in electrothermic smelting do a considerable business in refining crude spelter, waste products, etc., but do not figure importantly as ore smelters.

Siberia.—A fairly large plant exists at Ekibastus, but having been completed only at about the beginning of evil days in that country, it has not yet made much more than experimental production, and during the last year or two has been idle. However, this plant will probably be a considerable source of spelter some day.

India.—The Burma Mines Corporation is drawing plans for a plant to make 10,000 tons of spelter per annum at Sakchi, which will probably be completed and producing toward the end of 1920.

China.—There is a small production of zinc in native furnaces in China. This country is always a potential producer. A few years ago the erection of a plant there was considered.

Japan.—This country has produced as high as 60,000 tons of spelter per annum, and probably has capacity in excess of that, but finds its main difficulty in getting adequate ore supply. The Australians have not been keen about supplying ore to Japan, but the Japanese will undoubtedly get what they need from Siberia and China in the course of time.

Australia.—There is a small production of distilled spelter at Port Pirie, and of electrolytic spelter at Risdon (in Tasmania). The Risdon production at present is at the rate of about 3000 tons per annum, but it is contemplated to increase it to 30,000

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tons as rapidly as possible. The Mount Lyell interests are also planning to produce electrolytic spelter from ore from the Roseberry mine.

Canada.—Trail has a capacity of producing perhaps 15,000 tons of electrolytic spelter per annum, but there has been doubt if economic conditions in British Columbia are as favorable as they ought to be. However, according to its last report, the Consolidated Mining and Smelting Co. has made such improvements in its metallurgical methods that zinc and lead can be produced at a profit on any market that has existed in recent years, providing that costs of labor and materials fall with the prices for the metals. It is said, moreover, that the Sullivan mine has developed into "one of the most valuable mineral deposits in America if not in the whole world."

Mexico.—A small plant (distillery) is under construction at Saltillo. Petroleum is to be the fuel.

The important thing to be deduced from the above summary, it seems to me, is what I have remarked in previous papers, to wit, whereas zinc smelting was for more than a century confined to certain districts where there was experienced labor, and it was considered venturesome to try any experiments outside of them, there is no longer such hesitation. Thus we now see zinc-smelting projects under way or in contemplation in all parts of the world.

ZINC MINING IN FOREIGN COUNTRIES

Australia.—The *Board of Trade Journal* of the British Government of Jan. 9, 1919, gives the following account of the Australian situation:

In connection with the action taken by the Commonwealth Government to organize the metal resources of Australia, a short review of the position so far as the production of zinc and the development of related industries are concerned has been communicated by the Electrolytic Zinc Co. of Australia to the Acting Prime Minister of the Commonwealth. Although the British Empire contains the greater portion of the more easily available zinc ores of the world, it produced before the war, according to this review, less than 70,000 tons annually of primary spelter or zinc, while the consumption of this metal in the United Kingdom alone amounted in 1913 to 195,000 tons.

Pre-war Australia exported annually zinc concentrates equivalent to 200,000 tons of spelter. The enormous demand for zinc of high purity gave rise to a rapid development in Canada and the United States of electrolytic processes for the manufacture of this metal. Very shortly afterwards attention was turned to the possibility of establishing this industry in Australia, and as soon as hydroelectric power became available in Tasmania one of the principal zinc-concentrate companies commenced investigations with a view to working out the application of the electrolytic process for the production of high-grade zinc from Australian ores. Construction work was started at Risdon, near Hobart, in January, 1917. From March, 1917, the first small unit was in operation, and later, the first larger unit designed to produce 25,000 pounds of zinc daily was started and has since operated continuously.

From an Australian point of view the application of zinc to the recovery of gold from cyanide solution and to the desilverizing of lead is of immediate and everyday importance. Zinc is also used in large quantities in the form of rolled blocks to protect ships' boilers from corrosion, and in the form of rolled sheet and strip for roofings, gutterings, etc.

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Sulphuric acid is a by-product of the process of zinc manufacture, and the industry will afford a valuable source of this commodity, with the result that Australia will not be dependent upon imported brimstone and pyrites as in the past. Sulphuric acid is now being made at Broken Hill to the extent of approximately 100 tons weekly from the sulphur in the zinc concentrates, thus replacing imported sulphur, which is very expensive and difficult to obtain. The desulphurized ore is being shipped to Hobart for the extraction of the zinc. The consumption of acid at Broken Hill is relatively small, and steps are being taken to desulphurize the bulk of the ore at other industrial centers, where the product will be available for superphosphate manufacture and for other chemical industries.

The development of the zinc industry in Tasmania involves the shipment of large quantities of ore from Broken Hill via Spencers Gulf and gives, consequently, good opportunities for economical back-loading. This will be of material assistance to the timber trade of Tasmania and will permit the substitution of Tasmanian hardwoods for imported timber. This arrangement is now in operation, and approximately 250,000 superficial feet of timber is delivered at Port Pirie each month for the use of the Port Pirie smelters and the Broken Hill mines.

The program of development includes all other zinc products (in addition to the metal itself), which in the past have been produced mainly outside the Empire, and largely in Germany. The importance of establishing a domestic production of these materials is obvious, since the rubber and paint industries with all their ramifications are dependent on them and can not operate without them. These include zinc oxide in various grades and lithopone. It is possible to produce in connection with the electrolytic process the higher grades of oxide, such as are used in enamels and white rubber goods, as well as the less refined materials for paint manufacture. Lithopone is a pigment which is rapidly increasing in popularity and finds extensive application in some classes of rubber goods. The first unit of a lithopone plant, which will have a capacity of 5 tons daily, is now under construction and will be started shortly.

Zinc-oxide manufacture on a preliminary scale is in operation, and production will increase rapidly. A plant of British manufacture capable of producing 200 tons monthly of rolled zinc sheets will be installed at Hobart early this year. The zinc produced at Hobart has, to date, averaged over 99.9 per cent. zinc, and is probably the highest grade in the world. This grade of zinc is the only kind that can be used for galvanizing telephone wires, as the ordinary metal gives a coat which cracks on bending. For special purposes electro galvanizing is adopted, and this also is to be developed at Hobart. Castings for ornamental purposes are principally made of zinc, for which very high-grade metal only is suitable, and this industry is to be taken up.

Zinc alloys and products are extensively used commercially, and the demand for these is certain to increase very considerably with the development of local industries. When additional power is available it is proposed to establish a number of electrochemical industries for the production of materials essential from the point of view of making Australia self-contained and independent of foreign sources of supply.

The Risdon plant in Tasmania should have a big future ahead if prospects are justified by events. Current production is about 10 tons of fine spelter a day, to be increased shortly to 15 tons. To produce this a 4000-hp. plant is employed, but it is intended ultimately to utilize a 30,000-hp. installation. In a few years Tasmania, therefore, should

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be treating from 80,000 to 100,000 tons a year of zinc concentrates, with an output of about 35,000 to 40,000 tons of fine spelter.[1]

Belgium.—Official figures give the production during the period of the war as follows:

ZINC PRODUCTION IN BELGIUM
(In metric tons)

Year.	Spelter.	Sheet.
1913	204,220	51,490
1914	145,925	30,780
1915	51,660	21,350
1916	22,930	8,045
1917	10,290	1,675

An official report has been compiled for the Belgian Government, dealing with the situation of Belgian industries in February, 1919. The zinc works in the province of Liege produced in 1913 113,000 tons of spelter and employed 4600 workpeople. The Dumont works at Sclaigneaux has been very seriously damaged, and only four furnaces remain in a fit state for working. The greater part of the plant will have to be rebuilt, and a long time must elapse before production can be resumed. Other works in the Liege district have sustained comparatively small damage. They were running during the earlier years of the war, but with a steadily decreasing output, owing to the lack of raw materials. These works can all be set going again as soon as raw material is available, but it is very difficult to say when this will be forthcoming, and what will be the industrial and other conditions when they can get to work again. In the province of Limberg there are three spelter works, of which two belong to the Overpelt-Lommel concern. The third, constructed at Rothem shortly before war broke out, commenced operations in 1914, and has been shut down since the end of that year, the plant, however, remaining in good condition. The works at Overpelt and at Lommel remained in operation, though on a decreasing scale throughout the war. At present, however, they are completely shut down owing to the lack of ore. In 1913 the ore consumption of the Overpelt-Lommel works was 73,370 tons, of which 51,543 tons, or more than 70 per cent., came from Australia. During 1918 these plants had at their disposal only 15,890 tons of ore, of unknown origin, but coming probably from stocks seized at other works.

In the province of Antwerp the Boom works, which supplied 6860 tons of spelter in 1913, has only produced a few hundred tons since the war broke out. The plant has been at a standstill since 1917, and its stocks of raw materials and part of its equipment have been removed.

It is stated in the report that the importation of foreign furnace

[1] *Metal Bull.*, Dec. 13, 1918.

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material, especially Australian concentrates, is indispensable if the Belgian spelter works are to be put on their feet again, but it is said to be a question whether the treatment of these concentrates by Belgian works will be possible in future, owing to the excessive costs of fuel, refractory materials, and other requisites. On the other hand, the establishment of a reasonable buying formula for Australian concentrates is a very troublesome matter, for the simple reason that an exact calculation of the probable cost of treatment is difficult, if not impossible.

The damage to the Belgian zinc industry amounts to considerably more than the strictly material damage to the plants, for while the Belgian production has been cut from over 20 per cent. of the world's production to almost nothing, other countries have had excessive demands put on them, and have materially increased their productive capacity, in order to carry the extra load. This will make the problem of reinstatement of the Belgian industry a heavy one, dependent entirely as she is on the importation of foreign ores.

Canada.—Concerning the spelter bounty in Canada the *Metal Bulletin* of Aug. 2, 1918, contained the following:

"A Bill has been passed in the Canadian House of Commons for payment of bounties on locally produced spelter. It provides that whenever it appears to the satisfaction of the Minister of Trade and Commerce that the standard price of zinc or spelter in cakes, blocks, or pigs, in London, is less than £41 8s. 6d. per ton, the Governor in Council may authorize the payment out of the Consolidated Revenue Fund of a bounty on zinc or spelter, containing not more than 2 per cent. of impurities, produced in Canada, at the time the price is as above stated, from zinc ores mined in Canada. Such bounty shall be equal to the difference between such standard price per ton and £41 8s. 6d. per ton, but shall in no case exceed 2 cts. per pound, and in no event shall any bounty be paid when the price received for such zinc and spelter by the producer is 9 cts. or more per lb. No bounty shall be payable on zinc or spelter produced after 31 July, 1920, and the total amount payable shall not exceed $400,000."

From the preliminary report on the mineral production of Canada by the Canadian Department of Mines it is ascertained that previous to 1916 all zinc ores mined in Canada were exported for both smelting and refining, but during the last 3 years much of the ore has been treated in Canada, following the establishment of the electrolytic zinc refinery at Trail, B. C., by the Consolidated Mining & Smelting Co. The production of refined zinc was 2974 tons in 1916, 9985 tons in 1917, and about 12,278 tons in 1918.

The total production of zinc during 1918 from Canadian ores—in-

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cluding, in addition to the above refined production, the estimated recovery from ores exported (20 per cent. allowed for smelter losses) amounted to 33,663,690 lb., which at the average price of spelter in New York would have a total value of $2,746,620, as against 29,668,764 lb., valued at $2,640,817, in 1917.

Quebec in 1918 is credited with 2,652,526 lb. and British Columbia with 31,011,164 pounds.

The total zinc ore shipments in 1918 amounted to 121,363 tons, with a metal content of 62,361,486 lb., as against total shipments of 116,489 tons and containing 64,655,713 lb. of zinc in 1917.

Germany.[1]—The zinc ore output of Upper Silesia is officially given as being as follows during recent years, the figures representing metric tons: 1912, 522,000; 1913, 508,000; 1914, 435,000; 1915, 317,000; 1916, 434,000; 1917, 438,000.

The German spelter production in 1918 is given as 336,000 tons, 280,000 tons from domestic and 56,000 tons from imported ores. The output from domestic ores in 1917 was 180,500 tons and in 1916, 196,500 tons. Last year Germany exported 105,000 tons of spelter. At present the production from home ores exceeds the demand, and although this will increase with the restoration of normal economic conditions, there will be no necessity for Germany to import zinc ores for a long time to come.

The Upper Silesian Spelter Works in Kattowitz produced last year 11,804 metric tons of spelter and zinc dust against 10,534 tons in 1916. The tonnage of zinc sheets rolled was 1228 against 1868 in the previous year.

The spelter works are still dissatisfied with the selling price of spelter, in spite of the recent advance to 130 marks per 100 kilos. This price, it is said, does not nearly cover the cost of production, but it is doubtful whether the authorities will sanction any further rise, for this would merely lead to fresh demands on the part of labor. The general position is therefore unsatisfactory, especially as there is still overproduction, owing to the reduced consumption since the armistice. It had been thought that spelter would largely replace copper and brass for many purposes during the reconstruction period, but the stocks of these two metals are now reported to be much larger than had been thought possible, and meanwhile, the War Metal Co., as well as the spelter producers, have large stocks, for which there is only a small export outlet. It is probable that some works may be forced to shut down owing to excessive costs, and many have only been running lately for the sake of their by-products.

[1] *Metal Bull.*, Apr. 3 and 25, 1919.

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Guatemala.[1]—The largest showing of zinc in Guatemala is found in the Department of Chiquimula, near Concepcion. The zinc occurs in a lime-porphyry contact with lead and copper. These deposits were taken over by the International Railways, and a 25-ton concentrating mill built on the ground. The group consists of some 20 claims, 12 of which have Government titles. The operating company shipped from this district several hundred tons of calamine ore and zinc carbonates, and in addition considerable zinc concentrates and lead concentrates. The field will be promising when better transportation facilities are at hand.

India.—The *Engineering and Mining Journal*, Feb. 22, 1919, published a report of the Burma Corporation, Ltd., from which it is learned that plans are under way for the erection of a zinc smelting plant at Sakchi, India, for smelting the Burma ores of the corporation. The location is advised by Lawrence Addicks, the consulting engineer, as most desirable, because the Tata Iron and Steel Co. has extensive furnaces at this point, and will absorb a large portion of the product. The Burma Corporation has received valuable additional concessions from the Indian Government, a guarantee of a loan of £200,000, assistance in securing water rights and offers of low royalties. The ore reserves at the end of 1917 indicated 25 oz. of silver per ton, 27 per cent. lead and 19 per cent. zinc.

Japan.—Zinc production in Japan in 1917 amounted to 53,852 long tons, according *The Ironmonger*. The probable output of zinc during the first half of 1918 was about 10,983 long tons, this indicating a decrease which is probably due to the great reduction in imports of zinc ore from Australia and Tonkin during 1917, and to the decrease in the imports of old Chinese copper ("cash") which were exceptionally large in 1917 and yielded about 20 per cent. zinc when melted.

JAPANESE EXPORTS OF SPELTER, IN LONG TONS (*a*)

To	1916.	1917.	1918.
British India	400	2,000	3,464
Great Britain	7,889	18,500	4,116
France	2,609	5,300	6,971
Other Countries	11,368	10,200	2,078
Total	22,276	36,000	16,649

(*a*) *Metal Bull.*

Mexico.—The International Zinc Ore Co. is building a zinc smeltery at Saltillo, Mexico, but owing to the great difficulty in obtaining material and machinery from the United States in 1918, construction had to be interrupted last June. The company is building two Belgian distilling furnaces of 300 retorts each, which will be fired with petroleum. It has

[1] *Comm. Rept.*, Jan. 10, 1919.

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completed an eight-grate furnace to make zinc oxide direct from ore. At present the company is confining itself to blende roasting, shipping the product to American smelters. Construction of the plant will be resumed this year.[1]

In *Commerce Reports* dated Apr. 28, 1919, is contained the information that the calamine ore mines of the Piedras Negras district are running at full capacity, but, owing to the low prices for the past 6 months, very little of the ore has been exported to the United States, the companies holding it until the prices of zinc increase. When this metal is in demand the mines average approximately 10,000 tons a month. It is not expected that production will be resumed on a large scale until the price advances in the United States, as the cost of production and of shipping of a low-grade ore such as is mined in this district exceeds the cost of the production in the United States.

Siberia.—Years ago large and important deposits of lead, zinc, silver, and other minerals were discovered in the vicinity of the Tiutihe River, in eastern Siberia, north of Vladivostok. According to *Commerce Reports* of Jan. 2, 1919, J. I. Bryner, owner of many claims, succeeded in interesting Baron Hirsh in these deposits. The country was prospected and opened up in a businesslike manner, and a few years before the war a large amount of German capital was invested in the opening of several silver-zinc mines, in the construction of a railroad about 30 miles long, in dredging the mouth of the river, and in building wharves, houses, and similar accommodations. On Aug. 20, 1918, this mining undertaking, because it represented German interests, was seized by the Russian Government and offered for sale.

Spain.[2]—Zinc exports from Spain in 1918 were 54,761 long tons of ore and 3828 tons of spelter, compared with 36,669 tons of ore and 7235 tons of spelter in 1917.

Sweden.—The Swedish output of zinc ore in 1917 was 51,312 metric tons compared with 60,700 tons in 1916.

Metallurgy of Zinc[3]

By W. R. Ingalls

In the metallurgy of zinc in 1918 there were few if any striking revelations of new principles, but certainly there was a good deal of new thought, tending toward improvement in the art.

Roasting.—There is perhaps no branch of the metallurgy of zinc in which there is more need for improvement than there is in means

[1] *Eng. Min. Jour.*
[2] *Metal Bull.*
[3] *Eng. Min. Jour.* Jan. 11, 1919.

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and methods for desulphurizing blende. The increase in supply of flotation slimes has simply aggravated old difficulties. Practice has settled down upon the Hegeler, Merton, Ridge, and Spirlet as the standard mechanical muffle furnaces, but among these only the Hegeler finds general application. Mr. Rissmann and his assistants have remodeled the Spirlet furnace, and find it satisfactory, but other American smelters who have tried it have not been so well pleased. Similarly, the Merton and Ridge furnaces have come into occasional use, especially in Great Britain, without as yet meeting with general approval elsewhere. The Wedge furnace has possibilities, but has not yet been tested adequately under conditions where dead-roasting is necessary. In places where hand-raked furnaces are still permissible, by virtue of labor conditions, the Delplace would probably be adopted in preference to any other.

Mr. Rissmann has expressed the opinion that entirely too little attention had been paid to the roasting of ore. He, and his aids, formerly entertained the conventional opinion that when the sulphur is low in the roasted ore there would be good results in the distillation. They have found in some cases, however, especially in the roasting of flotation slimes, that there are better results with 2.5 per cent. sulphur left in the ore, providing the roasting conditions were right, than there are with only 0.5 per cent. sulphur left in the ore when the roasting conditions were wrong, referring especially to too great excess of air. They find, moreover, that ore roasted without too much excess of air will sinter and become more porous and otherwise favorable for distilling than ore roasted with too great an excess of air. Bearing upon this subject is the remarkable experience in desulphurizing blende at Port Pirie that has been reported this year.

The Dwight & Lloyd sintering process has been applied by C. N. Warner and Gilbert Rigg with promising results for the desulphurization and sintering of zinc sulphide concentrates at the Port Pirie smeltery of the Broken Hill Associated Smelters, Proprietary, Ltd. It has been found practicable to reduce flotation concentrates from 26 per cent. sulphur down to less than 1.5 per cent. sulphur at a very rapid rate. A portion of the gas, but not all, may be used for sulphuric-acid manufacture. The desulphurization seems to be remarkably cheaper than in even the best types of roasting furnaces, and the first cost of plant is much smaller. Moreover, the sintered product gives astonishingly improved results in distillation, it having been found possible at Port Pirie to charge the retorts with 16.6 per cent. more ore with the use of 10 per cent. less of reduction material, while recovery of zinc increased 4.3 per cent. and there was slightly less loss of retorts. These figures were obtained by 4 months of operation with roasted and sintered

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blende, 50 tons per day being used, compared with the previous record of 6 months when the furnaces were distilling ore roasted in Hegeler kilns.

Distillation Furnaces.—American zinc-smelting practice has settled down to two types of distilling furnaces, viz., the Hegeler and the Neureuther modification of the Siemens-Belgian. Only at Pueblo has the Rhenish type of furnace come into steady use in this country. This is the more interesting inasmuch as the Rhenish type of furnace is the favorite in Europe, and the new and modern metallurgy of zinc in Great Britain is trending strongly in its direction.

At Peru and Depew, Ill., the Siemens-Belgian furnaces use only 0.9 ton of heating coal per ton of ore charged into the retorts. At Rosé Lake the ratio is about 1 : 1. Between Rose Lake and Hillsboro, which are owned by the same company and are under the same metallurgical direction, we are able to get a good comparison of the Siemens and Hegeler furnaces. Rose Lake, with Siemens furnaces, uses about one ton of heating coal per ton of ore distilled and uses an additional half ton for the generation of power, a total of 1.5 tons per ton of ore. Hillsboro gets its power from waste-heat boilers, but its furnaces require about 48 tons of coal for distilling 18 to 20 tons of ore, or about 2.5 tons per ton of ore, wherefore Rose Lake is about a ton ahead of Hillsboro. Each plant uses about 0.5 ton of coal per ton of ore in roasting.

Mr. Ziesing has patented a modification of the Hegeler-Iola furnace in which the combustion gases pass longitudinally through the laboratory of the furnace. Between each section of retorts (4 × 5) he introduces a wing-wall extending outward nearly to the front of the furnace. The idea is to cause the burning gases to travel near the front of the furnace and eddy back in the several sections, with a view to securing a more uniform heating of the retorts. Mr. Ziesing tells me that he is building all of the Grasselli furnaces along these lines and reports that "as in most cases of this kind, it is a difficult matter to state in absolute figures just what the advantages are." He feels, however, that he gets better results by reasons of the fact that the fronts of the furnaces become hotter. The fact that the front half of the retort ordinarily, on account of the radiation, is colder than the rear half of the retort, is a matter that he has been trying to overcome for a long time, and by various means. He is also of the opinion that the furnace is more easily controlled as to uniformity of heat and that there is a slight saving in fuel consumption.

Distilling Practice.—More and more attention is given to proper compounding of the charge, especially as to slag constituents. O. Mühlhaeuser, says:[1] "The amount of slag formed in the retorts during

[1] *Metal u. Erz*, 1918, 15, pp. 303–305.

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distillation should be small, and its composition should be controlled by mixing the charge in suitable proportions, so that it has as little action on the retort as possible. An average slag sample obtained by distilling a mixture of Joplin and Wisconsin ores was found to have an oxygen ratio of 1:2.8, approaching that of a trisilicate. It was very viscous at distillation temperatures and formed an internal coating, the thickest part of which was on the bottom of the retort. The latter was thus protected from corrosion, and the loss of zinc by escaped vapor was decreased."

Behavior of Silver in Zinc Distillation.—Butte & Superior ore assays 50.5 to 53.2 per cent. Zn, 2.4 to 4.7 Fe, 0.22 to 1 Mn, 2.4 to 3.6 Pb, 0.33 to 0.50 Cu, 11.6 to 14.1 per cent. insoluble, and 0.03 oz. Au and 14 to 18.5 oz. Ag per short ton. One ton of spelter is obtained, roughly speaking, from 2.5 tons of ore containing 40 oz. of silver. Of this spelter about 35 per cent. is derived from the first draw, 50 per cent. from the second, and 15 per cent. from the third. Spelter of the first draw assayed 0.164 oz. silver per ton and 1 per cent. Pb; of the second, 0.583 oz. silver and 1.5 per cent. Pb; of the third 1.178 oz. silver and 2.25 per cent. Pb. These analyses show that very little silver goes into the spelter. The first draw occurs 2.5 hours after charging and comprises the spelter distilled at the lowest temperature, wherefore the relatively low lead and silver contents. With the progressive increase of temperature, more lead and silver go over. The bulk of the silver remains in the residue. In a test extending a little over 2 years, figuring back to raw ore, the weight of the residue was 46.75 per cent. and its content of gold was 88.14 per cent.; of silver, 77.4; of copper, 78.5; and of lead, 47.75 per cent. of that in the raw ore. The silver and lead figures for spelter and residue will not check back to the original ore, owing to losses in roasting. These data show that the loss of silver and gold in zinc distillation is very small.

Zinc Burning.—The River Smelting and Refining Co. smelts partially desulphurized ore in reverberatory furnaces at Canyon City, Colo., the proper quantity of reducing material being added to the charge. By proper management it is said that slags low in zinc can be made. The volatilized fume is collected by bag filtration and is shipped to Keokuk, Iowa, for further treatment. At Keokuk the fume is dissolved in sulphuric acid and the solution of zinc sulphate is electrolyzed.

At Great Falls, on the other hand, Mr. Laist is reported to have given up the expulsion of zinc in his reverberatory smelting and is now volatilizing only the lead, letting the zinc go into the slag. The old principles of metallurgy obtain pretty well. If a highly silicious and calcareous slag be made, zinc can be kept out of it to a large extent. Slag assays

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of 3 per cent. or even 2 per cent. zinc are not unreasonably to be expected. However, such slags require high temperature and may necessitate the introduction of barren slag-formers into the charge; wherefore it may be more profitable to make an ordinary ferruginous slag and let the zinc go into it.

Electrolytic Extraction.—More and more is it evident that the greatest difficulties in the electrolytic process precede the electrolysis itself. Given the right kind of electrolyte, there is no great difficulty in performing the electrolysis; but it may be costly to remove impurities in the hydrometallurgical part of the process in order to obtain the right kind of electrolyte. Also, there may be difficulties in making an adequate extraction of zinc in leaching the ore. Mr. Laist ran up against the old difficulty from gelatinizing silica, and he has had to introduce a rather round-about method of dehydrating the silica and rendering it insoluble.[1]

[1] U. S. Pat. 1281031 and 1281032, Oct. 8, 1918.

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PROGRESS IN ORE DRESSING AND COAL WASHING IN 1918

By Robert H. Richards and Charles E. Locke

Acknowledgments.—This review could not reach its maximum value without the coöperation of the ore-dressing fraternity and the authors hereby acknowledge their indebtedness to all who have helped by supplying information, including A. J. Anderson, F. W. Bradley, W. A. Butchart, J. M. Callow, H. M. Chance, J. P. Channing, J. V. N. Dorr, W. L. Du Moulin, G. C. Foote, Rudolph Gahl, L. H. Goodwin, H. W. Hardinge, Charles Hayden, D. A. Lyon, H. A. Megraw, L. D. Ricketts, A. H. Rogers, G. H. Ruggles, W. G. Swart, C. F. Thompson, C. J. Trauermann, Traylor Engineering & Manufacturing Co., United Filters Corporation, A. P. Watt, and R. B. Yerxa.

General

War demands for large outputs undoubtedly retarded technical progress in 1918. The main lines of advance have been in the production of larger crushing machines, in the study of ball-mill work and of crushing in general, in the consideration of screening before concentration, in the proper application of flotation and in the simplication of flow-sheets. Flotation litigation still remains largely in an undecided state.

Crushing and Grinding

Rock Breakers.—In breakers the development follows along lines of simplicity and ease of accessibility to the interior and there is also a tendency toward larger machines to meet the demands for increased capacity, increased size of feed opening, and lower costs. The gyratory breaker is especially adapted where large capacity is required. The Traylor company is making this breaker with a width of opening of 60 in. and is prepared to build to 72 in. The 60-in. breaker will crush 2500 tons per hr. to 10 in.

Large jaw-breakers have the advantage where tonnage is not so important as the size of opening. The Traylor jaw-breakers run up to 66 by 84-in. feed opening and an 84 by 120-in. breaker has been designed.

An increase is noted in the tendency to install rock breakers under-

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ground wherever the operations are sufficiently large and centrally located to warrant it.

In the remodeling of the Alaska-Juneau mill described later, one of the changes was to substitute Gates 6D gyratory breakers for Gates 9K, which were found to be impracticable as secondary breakers to handle the large tonnage of ore to be crushed from 8 in. down to 3 in. Part of the trouble is conceded to have been due to the fact that the feed flowed into one side instead of all around the top of the crushing cone and this resulted in a leverage that seemed constantly to break the cone spindles. The feeding arrangement could not be changed because of lack of head room in the mill, but the No. 6D required less head room and corrected the fault. It is, however, the impression that the No. 6D is a better designed breaker than the No. 9K for the Alaska-Juneau ore.

A novelty in gyratory breakers is the Kennedy gearless breaker, which is a small gyratory designed for secondary crushing down to ½ or ¾ in. and operated by direct drive to the vertical shaft or spindle by means of belt or rope. Gears have a maximum limiting speed for safety, but the gearless breaker may be run at three times the safe speed of geared machines and thus get a corresponding increase in capacity. Another feature of this machine is that the concaves are set vertical, which gives nearly double wear by reversing them. The standard Kennedy ball eccentric is used. A mule stand is, of course, necessary to change the direction of the belt or rope when driving from a horizontal shaft. At first glance the horizontal pull of the rope against the vertical spindle appears to be a considerable factor, but this is said to be not nearly so troublesome as the vertical downward thrust of gears which necessitates the use of special lubricating rings at the bottom of the spindle. This breaker is claimed to have advantage of simplicity and economy of operation and power over rolls, disc crusher, ball mills, etc., in its special field.

Symons Crushers and the New Cornelia Plant.—The Symons crushers have found a great deal of favor during the past few years and for tonnage and capacity they are very hard to beat in their special field. It is necessary, however, to keep all tramp iron out of the jaws of this machine, as this material will cause trouble, break-downs and heavy repairs.

The New Cornelia copper leaching plant uses these machines very successfully for secondary crushing after gyratories. The ore is mined by steam shovels, is hard and breaks very coarse, so that there are a great many boulders, some as large as 4½ by 4½ by 10 ft. The first breaker in the primary crushing plant is a No. 24 Gates, style K, gyratory, which has a bowl sufficiently large to receive these lumps dumped directly from the 35-ton mine cars. This originally made a product 9 in. maxi-

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mum size at the rate of 500 tons per hour. This product goes to four No. 8 gyratory breakers, after passing over grizzlies with 3-in. spaces, and is there reduced to less than 3 in. It was found that the No. 24 breaker set at 9 in. would deliver ore to the four No. 8 gyratories faster than they could crush it, and consequently the discharge opening was reduced from 9 in. to 6 in. by installing thicker concaves in the bottom row and a thicker bottom section of the mantle. This throws more work on the large breaker and reduces the wear and repairs of the four smaller machines.

The grizzly undersize and the gyratory product from the primary crushing go to a 10,000-ton storage bin, which feeds the secondary crushing plant consisting of four units of 48-in. Symons vertical-shaft disc crushers. Each unit consists of one coarse Symons and two fine Symons, which are identical except that in the coarse machine the upper disc has grinding surface 4 in. wide, while in the fine machines it is 6 in. wide. The coarse Symons crushes 90 to 100 tons per hr. to ¾ in. with small cost of repairs, and this product is divided between the two fine machines, which crush to ¼ in. with rather heavy repair cost. Nevertheless these fine machines are considered satisfactory and produce a very desirable uniform product for leaching. Some weakness developed in them and they were strengthened by substituting cast steel for cast iron. Magnetic pulleys did not remove all the trouble from tramp iron, so that it was found necessary to install powerful magnets above the conveyors leading from the primary crushing plant.

The wear of manganese steel per ton crushed is 0.0032 lb. for gyratory mantles, 0.0081 lb. for gyratory concaves, and 0.059 lb. for Symons discs. The babbitt consumption per ton is 0.0045 lb. in the primary crushing section and 0.0097 lb. in the secondary crushing section. Power consumption per ton is 0.21 kw.-hr. in primary crushing and 0.701 kw.-hr. in secondary crushing. The total tonnage crushed in 1918 was 1,775,000 tons and the finished product showed 26.7 per cent. on 3 mesh, 17.3 per cent. on 4 mesh, 12.7 per cent. on 6 mesh, 9.0 per cent. on 8 mesh, 7.0 per cent. on 10 mesh, 4.9 per cent. on 14 mesh, 4.1 per cent. on 20 mesh, and 18.3 per cent. through 20 mesh.

Rolls.—Having seen the field of rolls invaded at the coarse end by Symons crushers and at the fine end by ball mills it is interesting to note that Traylor rolls are advertised 14 ft. diameter and 36 in. face. These are designed to effect material economy and simplicity in large crushing plants by taking material from a very coarse primary breaker and reducing large tonnages to commercial sizes in one pass, thus eliminating the succession of gyratory breakers and rolls with the accompanying conveyors and screens that have been necessary in the past to do this same work.

Gravity Stamps.—In the gravity stamp now used in many places for

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coarser crushing than the old California practice, it appears that the water consumption has not increased in proportion to the tonnage. The old practice, as averaged by Richards,[1] showed 6.68 tons of water per ton of ore with an average stamp capacity of 2.83 tons per 24 hr. Present practice at the Nevada Wonder mill, with a capacity of 18 to 20 tons per stamp through screens having ½ to 1-in. holes, shows a water consumption of 2.6 tons of water per ton of ore. Similarly at a California mill with a 20-mesh screen and a low drop the capacity is 7.5 tons per stamp per 24 hr. and the water consumption is 2.4 tons per ton of ore.[2] The natural conclusion is that water required by any given stamp is nearly constant or increases only slowly as the size of the stamp screen holes is increased or height of discharge lowered.

A departure from the usual rubber blanket under stamp mortars occurs in the Prestea Block A mill in the West African Gold Coast Colony. The mortars are supported on concrete foundations with sheet lead, ⅜-in. rubber and tarred hessian in between. Full details of the stamps in this mill are given by P. T. Bruhl.[3]

Chile Mills.—The Lane Slow Speed Chile mill has had considerable following, and the following information by J. H. McCormick[4] regarding its operation in the Barnes-King gold mill of Montana is of interest. Three 10-ft. Lane mills received the product from a No. 5 Symons gyratory breaker. Sizing tests of the feed and product are given in the table.

	Feed, Per Cent.	Product, Per Cent.
Over 3 in	0.4	....
3 in.–2 in	2.9	....
2 in.–1½ in	7.5	....
1½ in.–1 in	17.7	....
1 in.–¼ in	43.3	....
¼ in.–20 mesh	22.9	....
20–48 mesh	2.5	14.0
48–65 mesh		11.4
65–100 mesh		13.8
100–150 mesh	2.8	10.2
150–200 mesh		7.5
Below 200 mesh		43.1

This product was admirably suited to the earlier mill process of table concentration and amalgamation followed by cyanide percolation. In the remodeled mill, however, concentration and amalgamation have been discarded and the Lane mill product is ground in pebble mills for cyanide agitation. The Lane mills are reported to make a remarkable reduction, but leave some sand to be slimed in the tube mill. Repairs are required rather frequently and access to make repairs is difficult, making the mills unpopular with the attendants. Crushing costs, however, compare favorably with ball mills doing similar work, but the Lane product is too fine for regrinding in a pebble mill without undue consumption of pebbles.

[1] "Ore Dressing," Vol. I, p. 222.
[2] E. E. Carpenter and H. E. West, *Min. Sci. Press*, **116**, 7, 288 (1918).
[3] *Eng. Min. Jour.*, **106**, 54 (1918).
[4] *Bull. Am. Inst. Min. Eng.*, **140**, 1283 (1918); *Trans.*, **60**, 98; *Chem. Met. Eng.*, **19**, 283 (1918).

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Grinding Pans.—In the United States the grinding pan finds very little application, the chief reason being apparently that less attention has been given to its development than to the development of the tube mill. Such pans, however, find application in some parts of the world where sufficient attention has been given to their improvement, and it is claimed that they operate as satisfactorily as tube mills with no greater consumption of power or increased cost of operation. The successful operation of these pans requires constant pressure between the shoes and the dies, proper size of feed, and careful adjustment of the pulp density and the speed of revolution. These pans are better amalgamators than tube mills and at the same time yield a granular product without undue sliming.

Perhaps the best type of pan is the Cobbe-Middleton. At the Prestea Block A mill[1] in the Gold Coast Colony, the pulp from 110 stamps with 10-mesh screens goes to 16 Cobbe-Middleton pans provided with 14-mesh screens instead of the old-fashioned overflow method. These in turn discharge to spitzkasten to take out coarse sands for further grinding in three Wheeler pans. Two 70-hp. motors drive the 16 Cobbe-Middleton pans. No trouble occurs if the feed is kept evenly distributed and free from wood chips and also if the space between the dies and the pan side does not become clogged with heavy sand. Weekly clean-ups serve to remove the rich sands that accumulate between the dies. Constant pressure between the grinding surfaces is obtained through adjustable weights and levers which act to press the dies up against the shoes. These weights are kept unaltered at the maximum and, although the grinding capacity should not vary theoretically, yet a new set of shoes and dies does give the pan a greater capacity. Water is supplied to each pan through a ¾-in. pipe. If the pulp is too thick the pan may choke; if too thin the swirl is excessive. Sizing tests of feed and products are as follows:

	Feed, Per Cent.	Product, Per Cent.
On 30 mesh	25.82	2.64
On 60 mesh	22.27	34.37
On 90 mesh	12.15	16.51
On 120 mesh	4.95	6.19
Through 120 mesh	34.80	40.28

Ball Mills with Circumferential Screens.—One of the few rare instances of the use of screen ball mills is on high-grade Cripple Creek telluride ores, where Schmidt komminutors take the ore from coarse crushers and crush it to roasting size. Screen analyses of the product when the komminutor is fitted with diagonal slotted screens 9/64 by ½-in. are reported by Blomfield and Trott as follows:[2]

[1] P. T. Bruhl, *Eng. Min. Jour.*, **106**, 54, 82 (1918).
[2] *Bull. Am. Inst. Min. Eng.*, **140**, 1265; **143**, 1668 (1918); *Trans.*, **60**, 118; *Eng. Min. Jour.*, **106**, 400 (1918).

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	New Screens, Per Cent.	Worn Screens, Per Cent.
Over 5/8 in	1.1	6.1
5/8–1/4 in	2.4	5.1
1/4 in.–10 mesh	16.6	24.0
10–20 mesh	26.2	22.0
20–30 mesh	10.2	8.0
30–40 mesh	7.6	5.2
40–60 mesh	9.8	6.4
60–80 mesh	1.2	1.2
80–100 mesh	3.0	2.5
100–150 mesh	3.9	2.2
150–200 mesh	4.4	4.2
Below 200 mesh	13.6	12.9

The chief advantage of these mills lies in their ability to deliver a granular product in one crushing operation, and the product is low in fine material.

Ball Mills.—The cylindrical mill *versus* cone mill controversy which waxed hot last year appears to have died down, the final outburst being an article by C. T. Van Winkle[1] giving the history and results of the various tests in the Inspiration mill and some details of the installations in the Anaconda and Calumet and Hecla plants. This article was highly favorable to the cylindrical mill, but in the subsequent discussion the conical mill had its innings and the reader was finally left with the impression that both types of mills are good machines and that neither has any very marked advantage over the other.

The Inspiration mill still continues the use of Marcy mills for reduction from breaker size to 48 mesh in one operation and is apparently satisfied with the work. Others believe that this work can be more satisfactorily and economically done in two stages. One difficulty in this single-stage reduction lies in the maintaining of the gratings at the discharge end of the mill.

Sizing tests at Inspiration of the Marcy mill feed from the 48-in. Symons disc crushers and of overflow of the Dorr classifiers in closed circuit with the Marcy mills are as follows:

	Feed, Per Cent.	Product, Per Cent.
On 1½ in	14.6	....
Through 1½ on 1 in	16.6	....
Through 1 on ¾ in	10.6	....
Through ¾ on ½ in	7.7	....
Through ½ on ⅜ in	6.0	....
Through ⅜ in. on 3 mesh	6.0	....
Through 3 on 6 mesh	8.2	....
Through 6 on 8 mesh	3.0	....
Through 8 on 10 mesh	3.2	....
Through 10 on 14 mesh	2.8	....
Through 14 on 20 mesh	2.5	....
Through 20 on 28 mesh	1.6	....
Through 28 on 35 mesh	2.2	....
Through 35 on 48 mesh	1.6	8.86
Through 48 on 65 mesh	1.5	10.97
Through 65 on 100 mesh	1.3	12.44
Through 100 on 150 mesh	1.2	11.59
Through 150 on 200 mesh	0.8	7.65
Through 200 mesh	8.6	53.47

[1] *Bull. Am. Inst. Min. Eng.*, **133**, 175; **136**, 796 (1918). *Met. Chem. Eng.*, **18** 207 (1918).

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To accomplish this work, 1.76 lb. of forged steel balls, 5 in. in diameter, were consumed per ton of ore. The manganese-steel liners and the chrome-steel grates wore at the rate of 0.399 lb. per ton of ore. Power consumption for the Marcy mills was 9.48 kw.-hr. per ton of ore and to this should be added 0.04 kw.-hr. for the conveyors and 0.09 kw.-hr. for the Dorr classifiers.

The changes in the Miami mill mentioned in MINERAL INDUSTRY, **26**, 768, have now been completed so that in each section ¾-in. material from rolls goes to one Hardinge mill which delivers to a Dorr drag classifier. The overflow of the classifier goes to flotation, while the sand product is equally divided between two Hardinge mills, each in closed circuit with Dorr classifier. The overflows of these classifiers go to flotation. The total tonnage of the three ball mills is 1000 tons per day and the total power consumption is 7.57 kw.-hr. per ton. Coarse crushing to ¾ in., classifying, etc., will amount to about 1 kw.-hr., thus making a total of 8.57 kw.-hr. per ton. Sizing tests of feed to primary ball mill and the final products are as follows:

	Feed, Per Cent.	Product, Per Cent.
On ¾-in. round hole	1.1	....
Through ¾ on ½-in. round hole	13.8	....
Through ½ on ⅜-in. round hole	13.7	....
Through ⅜ on ¼-in. round hole	12.2	....
Through ¼ on ³⁄₁₆-in. round hole	7.4	....
Through ³⁄₁₆ on ⅛-in. round hole	9.3	....
Through ⅛ in. on 10 mesh	8.3	....
Through 10 on 14 mesh	4.4	....
Through 14 on 20 mesh	3.3	....
Through 20 on 28 mesh	4.0	....
Through 28 on 35 mesh	2.4	0.1
Through 35 on 48 mesh	2.7	0.4
Through 48 on 65 mesh	2.0	3.8
Through 65 on 100 mesh	1.5	14.2
Through 100 on 150 mesh	1.9	14.8
Through 150 on 200 mesh	1.3	6.3
Through 200 mesh	10.7	60.4

A trial was made in one of the sections of dividing the roll product evenly between the three Hardinge mills, each mill operating in closed circuit, but the product gave a larger percentage of material on 48 mesh. This experiment seems to show the advantage of stage reduction. The advantage of using the primary Hardinge mill in place of the rolls formerly employed appears not to be that any increased efficiency of crushing has been obtained. On the contrary, rolls may be more efficient than ball mills, but they require more attention and repairs and appear on the whole to be less reliable and more subject to shut-downs and consequently more troublesome than ball mills. Just where rolls should leave off and ball mills begin is a question. On extremely hard ores it may be wise to crush as fine as possible with rolls, say to ⅛ in., and then finish with ball mills, while on softer ores the Miami limit of ¾ in. is proper and even a limit up to 1 or 2 in. may be used on very soft material.

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The Hardinge mills are now made as small as 2 ft. in diameter for laboratory installations. Experiment has indicated that there is an advantage in feeding part of the water to this mill through a pipe in the discharge opening so that the stream impinges against the rising side of the mill about 2 ft. in from the collar of the bearing. The logic of this is that too much water at the feed end washes coarse particles toward the discharge end where they accumulate and are carried out with the thick pulp. Less water at the feed end will hold back these coarse particles in a thick pulp until they are further crushed. More water at the discharge end makes more dilution and aids classification, so that coarse particles are held back and only fine crushed ore overflows. It is possible that power measurements will show a further advantage by this device, in lessened power consumption per ton crushed.

The Homestake gold mill, noting the success of the Hardinge mill in replacing stamps at the Dome gold mill in Porcupine, is installing a conical mill for comparison with stamps on their ores.

The Engels Copper Co. in California has tested grated cylindrical ball mills against the conical mill and has adopted the conical mill.

Another point of discussion during the past year has been regarding the merits of ball mills with quick-discharge grating and lifters as compared with the older central or overflow discharge mill. Del Mar[1] claims that, while for a coarse unclassified feed the former may have an advantage, yet in the case of a feed where all the ore particles must be ground or of a feed finer than the holes in the grating, it may have a positive disadvantage in reducing the tonnage of the mill by causing the return of an excess of oversize, and also in increasing the wear of balls and liners. He believes that this is brought about by the lowering of the pulp level at the discharge end of the mill. He cites screen analyses and tonnage figures which show that a central-discharge ball mill has greater capacity of finished product than quick-discharge mill and at the same time it does not produce much more slime nor as much oversize to be returned for regrinding.

A number of actual examples are given of mills which have discarded quick-discharge gratings for central discharge and the various reasons assigned for the change may be summarized as follows: (1) Too much oversize circulating; (2) excessive wear of balls and liners at discharge end; (3) reduced capacity and choking; (4) higher power consumption with lower tonnage.

In opposition to Del Mar, Fairchild[2] claims that the personal equation of the mill operator has much to do with the showing made in favor of

[1] *Eng. Min Jour.*, **106**, 14 (1918).
[2] *Eng. Min. Jour.*, **106**, 311, 319 (1918).

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the central-discharge mill and further states that the lowering of the pulp level at the discharge end with accompanying increased wear of balls and liners is a fallacy.

Marcy[1] also denies that there is a lowering of pulp level or excessive wear in quick-discharge mills at the discharge end and cites reports of several large companies to this effect. If the quick-discharge mill is properly designed it can equal the central-discharge mill.

Tellam[2] supports Del Mar's contention and submits further evidence of actual examples of increased wear and decreased tonnage per horsepower where quick discharge is used.

The writers of this review are of the opinion that while the central-discharge ball mill may have shown superiority in many cases, the quick-discharge grating should not be universally condemned. Some of the difficulties with it have apparently been due to the attempt to make it function as a screen and thus have holes so small as to cause trouble from clogging. There appears to be logic in the quick-discharge mill when properly designed and when the grating is sufficiently coarse to avoid clogging. The grating should not be used as a screening device for the ore, as this is the function of the classifier in the closed circuit. In this connection the experience of the Alaska-Juneau with ball mills is very enlightening.

The Alaska-Juneau mill difficulties are considered in detail under "Examples of Practice" later, but the principle trouble was with the original 8 by 6-ft. grate and screen ball mill, which has been changed to an overflow mill. In the accompanying figure the upper half shows the original mill and the lower half the modified mill. The original mill was intended to be more efficient than stamps, but, as it turned out, it required three times the horsepower and five times the consumption of metal that stamps require for the same crushing capacity. One of the mistakes was the attempt to feed to it material considerably over 3 in. in size. This was remedied by taking out all over 2½ in. to be crushed in stamps. But the main difficulty was with the discharge end, where it will be seen that the pulp passed first through a coarse thick grating and then through a finer control screen. The grating had radial openings instead of circumferential as in the Marcy mill, and these radial openings tended to throw the material back into the mill instead of to discharge it as the Marcy grating does. The space between the grating and the screen became choked with balls, rubbish, oversize material, etc., especially when the moisture in the pulp was under 50 per cent. This also caused excessive wear. Whenever the space became choked, the mill

[1] *Eng. Min. Jour.*, **106**, 451 (1918).
[2] *Eng. Min. Jour.* **106**, 583 (1918).

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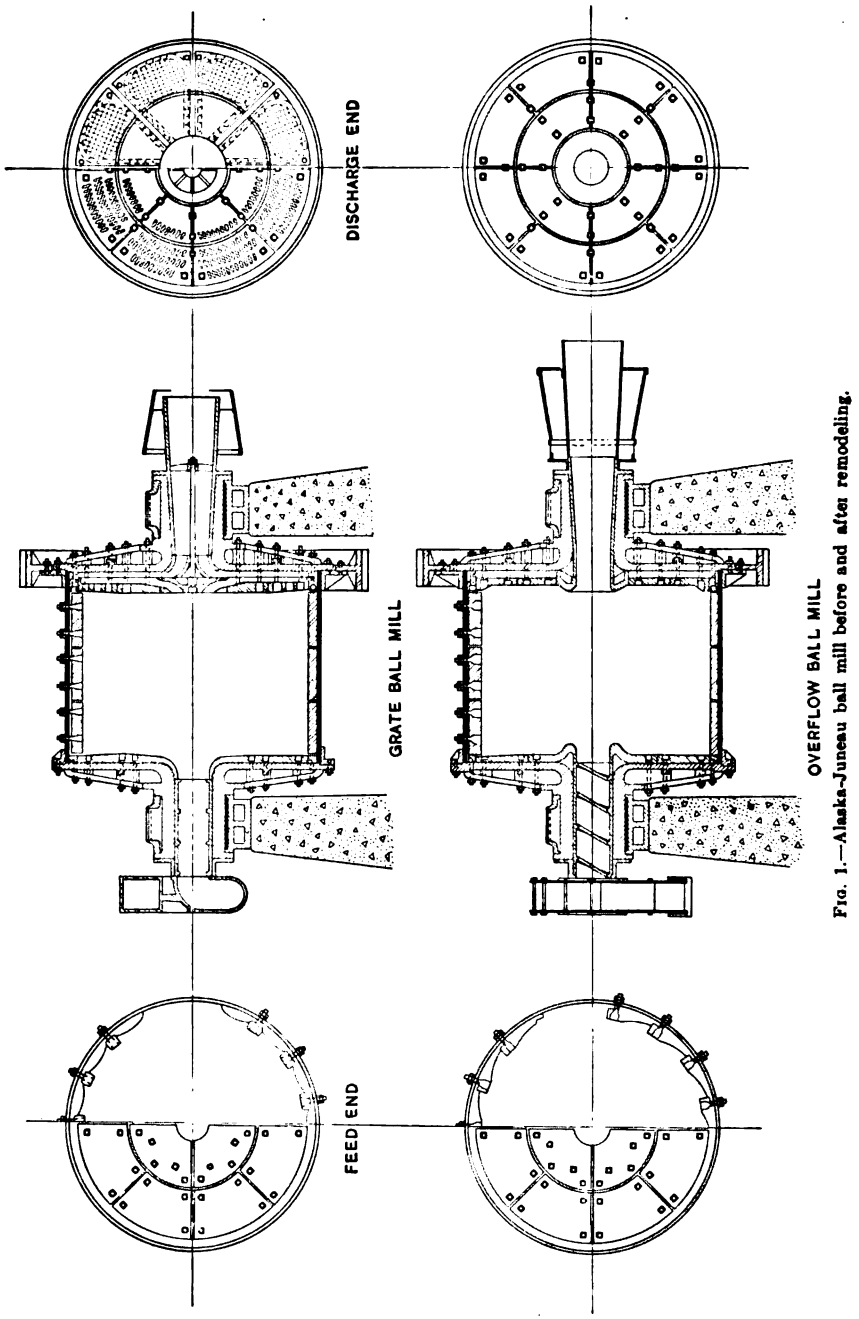

FIG. 1.—Alaska-Juneau ball mill before and after remodeling.

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had to be stopped, torn down and cleaned out by hand, a lengthy and expensive operation owing to the complicated parts. In addition to this trouble the space between the screen and the discharge end of the mill was not so large nor so efficient as in the Marcy mill, with the result that the space gave inadequate elevator cup capacity for lifting the crushed material out of the mill. Considerable trouble was experienced with the liners and with leaky bolt holes.

On the other hand the modified overflow type of ball mill in the figure can take a coarser feed and can discharge with a very much less percentage of feed water, so that it is expected that the wear of metal will be less than 1 lb. per ton against over 4 lb. before. The mill runs with less power, less effort, less jar and strain. The double trommel at the end of the discharge trunnion does all the screening necessary, and the returned oversize does not impair at all the capacity of the mill. The inner or coarse trommel will dispose of about 10 tons of barren waste material per day and the circulating load or the oversize of the outer or 7-mesh trommel to be returned to the feed end of the mill will amount to around 600 tons, or practically the same as the original tonnage taken and finished by the mill.

Ball-mill Operation.—In the discussion of the pros and cons of the various types of ball mills and of the best methods of operation the evidence of practice is of the highest importance. This has been well summarized by P. R. Hines.[1] He shows that, according to the cascading theory, when the mill is revolving at the proper speed the balls and ore are circling around a kidney-shaped center in which little work is being done. Some grinding by attrition occurs in this center and also at the circumference where the fallen balls pick up their motion again. Operating results bear out the fact that the greater the charge of balls the larger the inert kidney-shaped mass, and that when the balls occupy about one-third the volume of the mill the highest efficiency in tons crushed to a given mesh per kilowatt-hour is obtained.

The fineness of the product depends to only a small extent on the size of the holes in the grating, but rather on the tonnage fed, the water-to-solids ratio of the pulp, the size of balls and the efficiency of the classifier working in closed circuit, assuming that the size of feed, the ball charge and the speed remain constant. Increase in tonnage fed increases the coarseness of the product. A charge of mixed sizes of balls will produce a finer product than a charge of coarse balls alone.

The peripheral-discharge mill with grating differs from the center or overflow-discharge type in that the greater the amount of water added the coarser is the product. With mills provided with some form of

[1] *Bull. Am. Inst. Min. Eng.*, **134**, 251 (1918). *Eng. Min. Jour.*, **106**, 669 (1918).

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lifters at the discharge end the fineness and the amount of oversize can be controlled within certain limits. The function of the grate is to retain the ball charge in the mill and the holes should not be made so small as to make it act as a screen for the ore, as this will result in diminished capacity. The only proper method to produce a fine product is by the use of an external classifier in closed circuit.

Capacity of ball mills depends on fineness of grinding, weight or volume of ball charge, hardness of material, size of grate openings and size of balls, other factors remaining constant. Practically speaking, the most important limiting factors for capacity have been the size of the feed opening in the trunnion, the trunnion liner and the type of feeder. Tonnage and fineness of product are interrelated and as the tonnage increases the coarseness likewise increases. For any given mill it is possible to construct a curve showing this relation.

Excessive wear of liners and balls and an unnecessarily fine product result when a ball mill is run below its maximum capacity for a given ball charge. Capacity is reduced by hard ores and by a large ratio of reduction. Capacity suffers when balls of too small size are used or where the balls will not stand the shock of impact. Hard coarse feed requires steel balls up to 5 in. in diameter, while 4 in. will do for soft coarse ores and 2-in. steel balls will answer for regrinding hard ores. For regrinding soft ores, cast iron or composition balls may be used.

Where a fine product is desired with minimum amount of oversize, the grate opening should not be diminished. The grate bars should never have less than ⅛-in. opening. However, where a coarse product is desired for table work the grate may be used as a sizer and an open-circuit scheme adopted, and in this case the capacity and the coarseness of the product increases with the increase in the grate openings. When operating in closed circuit with a classifier, the capacity of the mill will suffer greatly unless the classifier is of the proper size and properly operated. The closed-circuit method of operation always has the advantage over the open circuit that the load in the mill can be held steadier and that the lightening of the mill and its running on balls alone can be prevented in this way.

Power depends principally upon the weight of the ball charge, being roughly 9 to 10 hp. per ton of balls, but it is also affected by the percentage of volume the ball charge occupies in the mill. Beginning with about 9 hp. per ton of balls when the mill is loaded half full, the curve rises more and more rapidly until it is up to about 15 hp. when the mill is only 20 per cent. full. This is explained by the fact that the center of gravity of the ball charge is further away from the axis of the mill. However, the smaller the volume of balls, the greater their freedom of action,

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so that the crushing efficiency is increased proportionately to the increase in power consumption per ton of ball load.

Reduction in two or more stages is commonly favored for making a product finer than 100 mesh, but for coarser products, such as 48 mesh, stage crushing, although used somewhat and appearing to have higher efficiency, is at a disadvantage from the viewpoint of first cost and simplicity, especially in the case of small plants. Practically the same result may be obtained by operating in a closed circuit with a large return oversize so that a great deal of the material may be returned to the mill six or seven times before it is finally reduced. A curve of power consumption per ton of finished product shows a rapid rise of power as circulating load is decreased.

As to the field of ball mills, they should not be used in preparing for concentration ore which contains a large amount of *coarse* mineral easily pulverized, but, properly operated, it is as good as any other grinding machine when it is necessary to crush to 12 mesh or finer to release the mineral, and for products 20 mesh and finer it has little competition. For fine crushing of gold ores for cyaniding, two-stage reduction in ball mills is favored by some on account of simplicity, small floor space, large capacity, and less operating troubles and attendance, although there is less economy in power and repairs than in a stamp and tube-mill plant of the same capacity.

Overfeeding will clog a ball mill and it will take from ½ to 2 hours to free itself. On large tonnages and coarse feed the area of the feed trunnion limits the amount of feed. Experiment has shown that a smooth trunnion liner instead of a spiral is best and also that a single scoop feeder with a long path of the spiral gives the highest capacity.

The water for fine grinding should amount to 33 to 40 per cent. of the pulp, but where a minimum of fine material is desirable the percentage moisture should be increased to 50 per cent. or more.

Ball consumption varies with the hardness of the ore, the fineness of the product, the quality of ball, and whether the mill is run in open or closed circuit. In general cast composition balls wear about twice as fast as forged or chrome-steel balls. Roughly for mills in open circuit delivering a coarse product through 8 mesh and containing 10 to 20 per cent. minus 200 mesh, the consumption of steel balls is around ½ lb. per ton of ore, and this will increase to around 4 lb. when grinding all through 200 mesh.

The wear of liners of either chrome or manganese steel is fairly constant at around ⅓ lb. per ton of ore regardless of conditions, unless the mill is run below capacity or below speed. The tendency is toward a general increase in weight and thickness of liners in order to reduce the

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proportion of scrap, which has been very high in the past. Smooth liners are probably as efficient as any, provided the mill is run at a slightly higher speed. Hard iron liners fail by cracking and breaking when used with 4- and 5-in. balls, but they stand up all right when 2-in. balls are used. Leakage around the bolts can be avoided by the use of large bolts, deeply countersunk, with double nuts which are screwed up tight two or three times when the mill is first put in operation. Candle wicking is commonly used for packing around the bolts between the shell and the washer.

In the field of fine grinding for cyaniding a rough rule for capacity of tube mills is 0.75 ton per cu. ft. of mill volume per 24 hr., including the returns from the classifier.[1] This assumes feed of the proper size and sufficiently dewatered. If the feed pulp is thin the speed of the mill should be reduced to avoid excessive wear of pebbles and liners. This or too coarse feed or very fine grinding will reduce the above figure on capacity. To give specific figures, a 4- by 16-ft. tube mill making 28.5 r.p.m. and consuming 25 hp. treated 100 tons of hard quartz ore per day from stamps through 4½-mesh screen. The pebble consumption was 2.2 lb. per ton of ore fed and the wear of metal liners 0.48 lb. Sizing tests of feed and final product showed:

	Feed, Per Cent.	Product, Per Cent.
On 40 mesh	38.7	0.0
On 60 mesh	12.0	1.0
On 90 mesh	16.5	22.0
On 200 mesh	14.8	25.9
Through 200 mesh	18.0	51.1

It was found that this mill would handle feed up to 4 mesh efficiently, but 3 mesh was too coarse. A mill 5 ft. in diameter, however, worked efficiently on 3-mesh feed.

Pebbles and Linings.—The problem of the proper grinding medium in tube mills is in general answered by determining which is the cheapest in the long run. Metal balls are to be preferred where they can be applied readily, but in some cases where the tube mill will not stand the extra weight of metal over pebbles or where for some other reason metal is objectionable, rock pebbles must be used. The operator then has the option of using imported flint pebbles, local pebbles, artificial pebbles or mine rock. Flint pebbles are the best, but in places where freight rates are high their cost becomes prohibitive and then one must use local pebbles or artificial pebbles or, as is common practice, feed hard mine rock into the tube mill. According to A. W. Allen,[2] where artificial pebbles or mine rock are to be used, blocks of rock of approximately spherical shape should usually be prepared slightly larger than the desired pebbles, and then, before using, they are roughly rounded in a tube mill for 10 hr. with a little water. This reduces the size and breaks off about

[1] F. C. Brown, *Eng. Min. Jour.*, **105**, 245 (1918).
[2] *Eng. Min. Jour.*, **105**, 1033 (1918).

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20 per cent. of material which otherwise would be broken off in the grinding mill, and this material would be ground with the ore, thus increasing cost of grinding and reducing capacity. Where a rock is used which does not chip off easily this treatment may not be necessary.

The three qualities to be determined are hardness, toughness, and resistance to abrasion. A tough rock may be better than a hard rock which is easily fractured. Tests in South Africa on hard quartz which fractured badly and a softer but tougher felsite showed less consumption of the felsite and increased grinding capacity of the tube mill.

Again, comparing imported high-priced flints with felsite, the tonnage crushed was practically the same, but the cost of the one-quarter ton of flints consumed per mill per day was $12, while the cost of one ton of felsite which was consumed per mill per day was $4.75. Allen considers that in fine grinding in tube mills abrasion plays considerable part and believes that the rough surface of the felsite is a better abrading agent than the hard smooth flint surface.

For determining suitable rocks for tube milling he suggests tests similar to those in common use for road material, including determination of specific gravity, density, absorption, hardness by Dorry hardness machine, toughness by Page Impact machine and wear by Deval abrasion machine. In view of the tendency toward the increased use of local rocks for grinding, it would seem well worth while to have such materials tested out along the above lines.

Where rock is used as a grinding medium three precautions should be observed: (1) Have the feed opening of sufficient size so that rock cannot jam in it. (2) Have a discharge grating to allow escape of pieces of rock which have become worn down so small as to have little grinding effect. (3) Do not fail to consider the presence or absence of metal values in the rock used for grinding, in calculating the costs of milling and the extraction.

While steel balls have largely replaced pebbles it is not certain that they are best in all cases. The advantage of pebbles on Lake Superior hard copper conglomerate has been already reported.[1] This advantage appears to be in the hardness of the pebble as compared with balls, which in no case equals the hardness of quartz ore. Furthermore flint pebbles cost around 1.5 cts. per lb. at Lake Superior, while metal balls cost 10 cts. per lb. Balls must, of course, be used for large feed or where maximum capacity is desired from the mill, but where the feed is less than ½ in. in size and capacity is not an important factor, pebbles may prove to be more economical. This point is of special significance in connection with the use of stage grinding by ball mills and pebble mills. Some of the

[1] MINERAL INDUSTRY, 25, 795 (1916).

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loss in capacity by pebble mills can be made up by increasing the diameter, thus making a large short cylinder.

In connection with the wear of tube-mill liners A. W. Allen[1] points out that it is important to watch for wear of the shell. If spaces exist between the liners and the shell, or if a liner, either of metal or other material, becomes worn, loosened, or broken, the sand will get behind it and wear the shell. Such a condition, unless immediately remedied, will result in serious damage or even breakage of the shell.

A possible source of tube-mill pebbles is reported by the Canadian Geological Survey as existing at Gabarus Bay, Cape Breton Island, where there are large beach deposits of pebbles of rhyolite and similar types of rocks. When tested in a Deval abrasion machine these pebbles showed greater resistance to abrasion than commercial flint pebbles.[2]

Among the materials for wearing-parts for ball mills, stamps, etc., are the New Process balls and linings made by the Eccleston Machinery Co., which are alloy products resulting from extensive experimenting, and which are claimed to be harder and more uniform than the standard balls and liners on the market.

The use of steel cylinders such, for example, as the so-called "sil-pebs" made by F. L. Smidth Co., instead of balls or pebbles for grinding, does not appear to have been extended into the field of ore crushing, but finds some application in cement work. In fact cement makers have now largely discarded pebbles for steel balls or cylinders. The "sil-pebs" are commonly $\frac{5}{8}$ in. in diameter and 1 in. long, but smaller sizes run down to $\frac{3}{8}$ in. in diameter and $\frac{5}{8}$ in. long. In some cement plants the tube mill has a grating and pebbles are used in the head section and steel in the discharge section. Whether steel cylinders make more fine powder than balls is not clear, but this may be the case, since fine powder is desired by the cement manufacturer. Theoretically a cylinder should have more points of contact on the ore and thus be more advantageous than a sphere.

Marathon Rod Mill.—No new developments are reported as to the Marathon rod mill during the past year, but it appears to continue in favor in those mills where it has been installed. The theoretical advantage of rod mills over ball mills seems to be well recognized, but the great drawback at present is that the rod mill has not reached such a stage of mechanical perfection as to make it generally satisfactory. The Burro Mountain copper mill is changing its flow-sheet so as to use these machines in two stages, as described more in detail later in this article under "Flotation," where the effect of the entire crushing process upon flotation is discussed. There is a possibility that this plant may

[1] *Eng. Min. Jour.*, 106, 867 (1918). [2] *Can. Min. Jour.*, 39, 146 (1918).

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put in Marcy and Hardinge mills in place of Marathon mills on account of advantages in floor space and feeding.

Crushing Practice.—Good crushing practice for a small gold mill is exemplified at the Elko Prince mill,[1] which treats 60 tons of hard brittle quartz daily. Mine ore goes first to a 30-ton bin covered with a 7-in. grizzly, and from this bin it is fed to a 2-in. shaking grizzly by a 24-in. Link-belt feeder. Oversize of 2 in. goes to an 8-ft. by 30-in. Jeffrey steel-pan picking belt and then to a No. 4 Telsmith gyratory breaker. From 5 to 10 tons of $2 waste are sorted out daily. A second 30-ton ore-bin is used for custom ores and delivers direct to the Telsmith breaker. The breaker product together with the undersize of the 2-in. grizzly is elevated and sampled in Vezin samplers and delivered to a 15- by 15-ft. cylindrical steel bin with center bottom discharge to a Challenge feeder and 12-in. belt conveyor leading to a No. 44 Marcy mill. This bin has an opening or tunnel in from the side at the bottom, 3 ft. high and 30 in. wide and extending in about 4 ft. to allow access to the inside for loosening sticky ore. The Marcy mill discharges to a duplex Dorr classifier in closed circuit with a Denver Engineering Works 5- by 14-ft. tube mill. The classifier overflow contains not over 1 per cent. coarser than 100 mesh and at least 78 per cent. minus 200 mesh.

The Marcy mill makes 36 r.p.m., contains 2200 lbs. of 4- to 5-in. balls, and crushes 54 tons daily from 2 in. maximum down to ¼ in. maximum, using 25 to 35 hp. The water in the feed is 39.4 per cent. The grates are of chrome steel and the liners are of manganese-steel. Balls (1.13 lb. per ton) cost 9.59 cts., liners cost 6.03 cts. and repairs cost 4.16 cts., or a total of 19.78 cts. per ton milled.

The tube mill makes 23 r.p.m., contains 14,000 lbs. of 4-in. Danish flint pebbles, and crushes 133 tons per day including returns, using 35 hp. The water in the feed is 35.1 per cent. Komata shell liners are used, consisting of manganese-steel angle bars and cast-iron filler bars and plates; the end liners are cast iron. Shell liners last 18 months; end liners last a year. The cost for pebbles (3.5 lb. per ton of ore milled) is 6.84 cts. and for liners 1.52 cts. per ton milled.

Sizing tests of the ore at various stages are as follows:

Mesh	Marcy Mill Discharge, Per Cent.	Tube Mill Discharge, Per Cent.	Classifier Feed, Per Cent.	Classifier Discharge, Per Cent.	Classifier Overflow, Per Cent.
On 10	15.5	....	7.4	9.1	.....
Through 10 on 20	17.0	0.2	9.4	7.9	.....
Through 20 on 65	28.1	9.1	17.7	26.8	.....
Through 65 on 100	5.9	15.6	12.0	19.4	1.0
Through 100 on 150	7.0	26.6	16.2	23.5	4.1
Through 150 on 200	4.4	13.6	8.9	8.5	13.4
Through 200	22.1	34.9	28.4	4.8	81.5

[1] J. V. N. Dorr and L. D. Dougan, *Bull. Am. Inst. Min. Eng.*, **140**, 1235 (1918); *Trans.*, **60**, 78.

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Wearing Parts of Crushing Machines.—High war-time prices mean greater economies. Where a forging hammer and a small reverberatory heating furnace are available many broken or worn parts can be remodeled and used again. The following are some instances of possibilities along this line:[1] breaker toggles and toggle blocks reforged or made new from old camshafts and other suitable scrap; stamp stems from old cam shafts or by welding on suitable scrap material, or from old stems fagoted; cams by drawing out worn cams or welding on new metal; worn heads reforged and rebored; shoes with shanks broken off, either draw out new shank from shoe or bore out shoe and sink in new shank, or weld on worn-out shoe; shoes by welding worn-out shoe on reforged tappet; dies from sections of old heads reforged or by welding several old worn-out dies or from tappets by cutting in half lengths and filling center with old shoes; camshafts by welding broken parts or by fagoting old stems; mortar liners by flattening out old camshafts and guides; blooms for stock made by welding together all sorts of old scrap. Doubtless many other examples could be cited of where savings are being made.

Theory of Crushing.—Now that the work expended in crushing is generally agreed to be computable on the basis of the Rittinger theory as applied practically by the Gates crushing surface diagram,[2] we have a definite unit for comparison of the relative amounts of work required for crushing different ores. The next step therefore appears to be to make an exhaustive research on all sorts of ores. A preliminary contribution has been made by L. W. Lennox,[3] who has submitted results of experiment on twenty-three standard ores from various localities. The method of making each test was to take a given ore and make up a definite weight having a definite proportion of each size according to a certain predetermined scale or sizing test. This was then put into a small laboratory ball mill with a definite amount of water and balls and ground for a definite speed for a definite time. The ground product was sized and the crushing surface diagram plotted. The tabulated results show that, taking Portland Cripple Creek ore as 1, the comparative crushing resistances vary from 1.33 for Calumet and Hecla jig tailings down to 0.37 for Ray Consolidated porphyry copper ore. One of the difficulties in such tests is to determine the proportion of material in sizes below 200 mesh, but Mr. Lennox has made use of a method which solves the problem as long as only relative work is to be determined. His results appear to be consistent in that the products show about twice as much work

[1] R. Craib, *Jour. Chem. Met. Min. Soc. So. Afr.*, **18**, 254, 291 (1918); **19**, 89 (1918).
[2] MINERAL INDUSTRY, **22**, 823 (1913); **23**, 823 (1914).
[3] *Bull. Am. Inst. Min. Eng.*, **140**, 1255; **142**, 1564 (1918); *Trans.*, **61**. *Eng. Min. Jour.*, **106**, 638 (1918). *Chem. Met. Eng.*, **19**, 284 (1918).

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done on them when the crushing period is 20 minutes as when it is only 10 minutes.

To the practical mill man this work may not appear to be of much value, but when one considers that not only the relative crushing resistances of various ores can be determined, but also the relative efficiences of different crushing machines on the same ore, it will be seen that a very important factor in the cost of milling can be investigated. It may be found that while a mill has been obtaining a high recovery of 90 per cent. or over of the metal values, the crushing machines may not have been working at over 25 per cent. efficiency in the production of useful grinding work on the ore.

This appears to be a prolific field for investigation and undoubtedly further research will develop further refinements of calculation as well as bring out methods of reducing to a common basis ores of different physical characteristics such as cleavage, etc., which cannot be compared directly by sizing tests.

Effect of Heating and Quenching.—It is well known that the friability of an ore is increased by heating or by heating followed by quenching, but it has remained for Arthur Yates[1] to study the effect of such treatment on tin ores from the viewpoint of the ore dresser. He found that tin ores are easier to crush after they have been heated, and still more easy after heating and quenching. Further, the effect of heating, and still more of heating and quenching, is to yield after crushing a product with a greater proportion of middle-sized particles, and a smaller proportion of fine slime. Finally, seven Wilfley table tests on raw, heated, and heated and quenched samples of crushed lump tin ores showed no improvement in recovery as a result of the heating in the case of six tests, but the seventh test on ore from one special mine did show an improvement.

Incidentally the investigation brought out the fact that in the case of tin ores the hard cassiterite does not crush down as fast as the gangue and consequently the fine slimes assay considerably lower in tin than the original ore. This is just the opposite to what occurs in the case of a brittle mineral such as galena. This impoverishment of tin slimes in crushing leads to the recommendation that the first step in concentrating tin ores should be to separate, as far as possible, the very fine slime from which very little recovery of tin could be expected.

Screening, Classifying and Settling

Grizzlies.—A new apparatus on the market is the Ross Automatic Drop Bar Grizzly Feeder,[2] which is designed to be placed in the end of a

[1] *Min. Mag.*, **19**, 334 (1918). From *Inst. Min. Met.*, 1918.
[2] *Eng. Min. Jour.*, **106**, 712 (1918). *Can. Min. Inst.*, **39**, 140 (1918).

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feed chute and to combine the functions of a grizzly and a feeder. It is made in the form either of a roll feeder or of a traveling-belt feeder, but in either case there are cross bars to move the ore forward and so spaced as to allow the undersize to drop through. The special feature of the device is that the cross bars are in pairs, one bar of each pair being attached to the traveling sprocket chains in the belt-form or to the end flanges or hubs in the roll-form, while the other bar is attached only to the first bar and, while on the upper side of the belt or roll, its ends rest in depressions in the sprocket chains or end flanges, but when it passes around to the underside it drops down and swings freely from the first or fixed bar. This absolutely prevents any clogging of the grizzly.

Fine Wet Screening.—The Maxton screen, which was described in MINERAL INDUSTRY, **25**, 796, is reported to be developing satisfactorily and to be doing good work in the mills where it is being tried out.

This question of wet screening *vs.* classification has been discussed by H. A. Megraw,[1] who considers that there is a field for the former, which is undoubtedly true. However, he follows this up with a claim that a sized product forms a better table feed than a classified product, and to this the authors do not agree.

The difficulties with fine wet screen have been low capacity, blinding, high wear and high cost, and also mechanical troubles where bumping or vibration has been used. If a successful fine wet screen is to be developed it will be along the lines of (1) gentle feeding to avoid wedging of ore particles in the meshes, (2) an ore layer only one grain deep and a quick removal of oversize in order that coarse particles shall not hold back the undersize, (3) little movement of ore on the screen, in order that the screen shall not be worn by the sliding of the ore, and (4) the elimination of shaking, vibrating or bumping devices.

Dry Screening.—Fine dry screening does not offer all of the difficulties that wet screening does and is used in special cases, but, as a rule, mill men do not favor it because (1) it requires drying of the ore, (2) it means a dusty mill, (3) the cost of milling is increased, and (4) complications result where the screened products are treated on wet tables and middlings are made that have to be rescreened for retreatment. Nevertheless, G. V. Bland[2] reports that the dry-screening process has been substituted for hydraulic classification in some of the tungsten mills of Boulder County, Colorado, with the resultant increase of extraction at a relatively small increase in milling cost. With these ores the concentrates have a very high value, but the mineral is friable, does not break free from the gangue, and is finely disseminated. This results in a large middling product and a large amount of slimes, so that a recovery of 75 per cent. of the tungstic

[1] *Eng. Min. Jour.*, **106**, 526 (1918).

[2] *Eng. Min. Jour.*, **105**, 908 (1918).

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oxide as a 55-per cent. product is very good work in ordinary mills, but dry screening raises the recovery to 85 to 95 per cent. as a 60-per cent. product.

In detail the scheme calls for dry screening with screens of 14, 20, 30, 50, 80, 120, 180 and 250 mesh, and the sized products are tabled. Rich coarse middlings are dried, reground, and returned to the original feed. Coarse tailings are reground wet and either classified or screened wet and treated again on tables. Slime middlings are retreated direct. Slime tailings are waste. One advantage of dry screening is that a table is not necessary for each sized product, but sized products can be accumulated in bins to be run when tables are available. The screens used are the Bryan sizer and the Bland screen, and with the latter it is claimed that it is possible to screen as fine as $\frac{1}{800}$ in.

The advantages claimed for the foregoing process are: (1) Control of pulp dilution and elimination of settling tanks, thickeners, etc., so that tabling is carried on with exactly the proper amount of feed water and thus at maximum efficiency, especially on the slime tables. (2) Independence of all important concentrating units so that a stoppage of one table does not shut down the whole mill. (3) Greater efficiency of sizing machinery as compared with hydraulic classification. This is true only if the screening is carefully and slowly done. The screen is a positive machine giving exact limits of sizes, while even the most perfect classifier gives a considerable range of sizes in a given product. (4) Greater efficiency of concentrating units on dry-sized feed as compared with classified or wet-sized feed. This point is debatable and the authors believe that this will depend upon the milling conditions in any given instance, and that under average milling conditions classification will yield better final mill concentration than screening.

The expense of dry screening limits it to high-grade ores. In the case of a low-grade ore it is proposed to grind, classify and table in the usual way, making concentrates, middlings and tailings. The concentrates and tailings would be final products, but the middlings would be rich enough to warrant drying and dry screening before retabling.

This dry-screening process of milling seems to be well worth experimentation on certain types of ores, and its reported success in the Vasco and other tungsten mills would indicate that it may be applicable in other districts having somewhat similar milling problems.

Classification.—Nothing particularly new has appeared along the line of hydraulic classifiers. Flotation has largely removed the necessity of close classification on sulphide ores below 48 mesh, the only requirement being that the slime shall be well removed from this material.

The Allen cone, described in MINERAL INDUSTRY **25,** 799, appears to

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be growing in favor especially where a thickened product is desired and where the use of water is to be reduced to a minimum. It serves as a classifier, as a deslimer, or as a dewaterer. As a classifier where high-grade work is not essential, a single cone or two cones in series may replace a hydraulic classifier. For desliming it is used in place of mechanical or hydraulic classifiers either in closed circuit in ball-mill grinding or to separate sandy table feed from slimy flotation feed. As a dewaterer it finds application on table feed or table concentrates, or even on table tailings where the tailings are to be stored or where water is to be recovered.

In the remodeled Burro Mountain mill these cones have disappeared, not because they did poor work, but because in the revised flow-sheet it has been found that dewatering in cones was not necessary.

Dorr Classifiers.—Material improvement in these machines has been obtained through experimental work and study of adjustment and regulation so that the amount of slime material remaining with the sand is considerably reduced. This classifier, materially strengthened for coarse work, is in very general use for making separations from 28 to 65 mesh for flotation.

At the Primos mill, Empire, Colo., a duplex Dorr classifier handling 200 tons of original feed per 24 hr. from a Marcy mill, makes a separation at 40 mesh with only 17.5 per cent. of minus 40-mesh slime in the sand as shown in the following table.

Mesh.	Marcy Feed, Per Cent.	Marcy Discharge, Per Cent.	Classifier Sands, Per Cent.	Classifier Overflow, Per Cent.
On 1 in.	30.4	.....	.....	.....
Through 1 on ¼ in.	50.6	.....	.....	.....
Through ¼ in. on 10 mesh	9.2	.....	.....	.....
Through 10 on 20 mesh	3.8	.....	.....	.....
Through 20 on 40 mesh	2.6	50.6	82.5	1.2
Through 40 on 60 mesh	1.0	14.3	7.7	8.5
Through 60 on 80 mesh	0.5	5.5	2.6	8.1
Through 80 on 120 mesh	0.4	4.6	1.4	10.6
Through 120 on 150 mesh	0.1	0.5	0.7	2.0
Through 150 on 200 mesh	0.4	4.6	1.0	12.6
Through 200 mesh	0.8	19.8	3.8	56.8

At the United Eastern gold mill two Dorr duplex classifiers have replaced two duplex 24-in. Callow screens, 20 and 30 mesh, operating in closed circuit with Marcy mill. Not only have the classifiers reduced the minus 20-mesh material in the sand return from 46.24 per cent. to 32 per cent., but there is a material saving in cost and repairs, and the mill feed is better regulated by the variation of the classifier gravity. The Callow screens handled load from 240 tons original ball-mill feed, the classifiers handle 260 tons. The returns on the 260-ton basis amount to 435 tons, thus giving a total feed of 695 tons.

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Mesh.	Ball-mill Discharge, Per Cent.	Classifier Sands, Per Cent.	Classifier Overflow, Per Cent.	Callow Oversize, Per Cent.	Callow Undersize, Per Cent.
On 14	27.0	55.0	.....	.....	.....
Through 14 on 20	11.0	13.0	1.9	53.76	1.9
Through 20 on 28	9.0	9.0	9.6	16.74	5.1
Through 28 on 35	7.0	5.0	10.3	9.80	8.8
Through 35 on 48	7.0	4.0	9.8	5.70	8.5
Through 48 on 65	6.5	2.0	8.4	3.70	8.7
Through 65 on 100	5.0	2.0	7.2	2.30	8.0
Through 100 on 150	5.0	1.5	6.8	1.48	9.5
Through 150 on 200	2.5	1.5	7.5	1.09	8.4
Through 200	20.0	7.0	38.5	5.43	41.1

For use where it is desirable to control the dilution of the overflow of the Dorr classifier within rather narrow limits, the hydrometer indicator has been developed.

The Dorr bowl classifier, described in MINERAL INDUSTRY, **25**, 798, and originally designed to remove slime, has been enlarged in size and application so that separations as coarse as 48 mesh are being made satisfactorily. For dewatering purposes, two 12-ft. bowl classifiers in the St. Joseph lead mill each handle 2100 tons of jig and table tailings containing 60 to 65 per cent. moisture and averaging about 30 per cent. between 9 and 2 mm. and 70 per cent. between 2 mm. and 150 mesh. The dewatered sands from the classifiers averaged 17 per cent moisture; the overflow is practically clear water except for a small amount of material below 150 mesh.

The two following sizing tests supplement that of two years ago on Golden Cycle ore in that the first goes down to 350-mesh screens and the second gives results with increased tonnage. The ore is silicious. The classifier is a standard 8-ft. machine with 15-ft. bowl. About 2 hp. are required to run it. It will be seen that even at the large capacity the sands contain only 7 per cent. finer than 200 mesh, while the slime overflow contains less than 8 per cent. coarser than 200 mesh.

Mesh.	Feed, 275 Tons (Dry). Slimes, 63 Tons (Dry). Water with Sands, 26.1 Per Cent. Water with Slimes, 95.5 Per Cent.		Feed, 1650 Tons (Dry). Slimes, 468 Tons (Dry). Water with Sands, 26.7 Per Cent. Water with Slimes, 89.8 Per Cent.	
	Sands, Per Cent.	Slimes, Per Cent.	Sands, Per Cent.	Slimes, Per Cent.
On 20	3.00	.....	1.8	.....
Through 20 on 30	8.30	.....	14.2	0.05
Through 30 on 40	13.50	.....	16.1	0.07
Through 40 on 60	24.60	.....	26.9	0.10
Through 60 on 80	3.00	.....	2.8	0.09
Through 80 on 100	10.20	.....	10.7	0.25
Through 100 on 150	12.40	0.01	11.1	1.25
Through 150 on 200	16.30	0.20	10.0	7.75
Through 200 on 250	3.65	0.37	6.4(a)	90.44(a)
Through 250 on 300	2.36	1.40	.....	.....
Through 300 on 350	0.46	0.80	.....	.....
Through 350	2.23	97.22	.....	.....

(a) Includes all below 200 mesh.

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Dorr Thickeners.—These continue in favor for settling, especially in connection with flotation. The difficulties met with in some mills settling flotation concentrates, due to accumulation of froth on top of the water, have been largely eliminated by more efficient sprays and baffles. The largest thickener now in operation is the 200-ft. diameter machine at the Inspiration mill. The use of the concrete tank for larger units has become more common and also the use of concrete ring in which wooden staves are fastened, using either an earth or concrete bottom. The percentage of installations of the tray type of thickener increased materially during the year, the Calumet and Hecla Co. alone having put in operation twenty-seven 3-tray machines ranging from 25 to 40 ft. in diameter.

While the area required to settle different types of concentrates varies within wide limits depending on the mineral constituents and their physical characteristics, as well as on the amount and character of the colloidal gangue, still for lead and zinc flotation concentrates an average figure will be between 10 and 15 sq. ft. of surface area per ton of dry solids per day. For copper flotation concentrates the range is greater, being from 25 to 60 sq. ft., with an average around 40 sq. ft.

The Dorr thickeners are finding a field in coal washers, as will be seen by referring to the subject of coal washing at the end of this article.

For use with Dorr thickeners the Dorr diaphragm pump has been improved so that very close adjustment is practicable, and the moisture in a silicious pulp discharge from it can be kept as low as 43.5 per cent.

The foregoing improvements in Dorr machinery and the extension of the applications of the same to all sorts of commercial classifying, leaching and settling problems are due in a great measure to experiment and research. For furthering such research the company has installed a very complete laboratory at Westport, Conn., where commercial experiment can be carried on quietly, completely, and without the interruption of a busy city.

Column Thickening.—A rather novel thickener or device for automatically separating solids from solutions, especially in leaching work, has been described by B. MacDonald.[1] It consists of a vertical cylindrical tank with a cone extending up from the bottom inside to about one-half the height of the tank. A cylindrical diaphragm, open top and bottom, is suspended in the tank with its top somewhat above the top of the tank. The diameter of this diaphragm and also the bottom diameter of the cone is about two-thirds the diameter of the tank. In the annular space between the diaphragm and the wall of the tank mechanical or pneumatic agitation may be carried on, and thus solid is held in suspension and the

[1] *Bull. Am. Inst. Min. Eng.*, **139**, 1141 (1918); *Trans.* **60**, 107. *Min. Mag.*, **19**, 101 (1918).

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specific gravity of the pulp is heavier than water. Inside the diaphragm, however, is quiet, and consequently this area is largely clear solution from which the solids have settled out and slid down the sides of the cone. The clear solution column inside the diaphragm is of lower specific gravity than the pulp outside and hence the height of liquid inside is greater than that outside on the principle of balanced columns. The result is that clear solution can be taken from the top of the inside column while thickened pulp can be drawn off from the outside column or annular space.

Slime Dams.—The South African practice in slime dams, including selection of site, digging of base or key trenches, distribution of pulp, arrangement of drainage channels, the slope of the walls and the actual operation of maintaining the channels and walls by shoveling, has been discussed in detail by J. E. Thomas and E. A. Osterloh.[1]

Hand Sorting, Jigs and Tables

Hand Sorting.—The problem of ore sorting is always a prolific source of discussion and is one that must be decided by the conditions existing at each separate plant. The ultimate deciding factor is, of course, whether sorting will yield a greater profit or not, but it is not always easy to make exact calculations, owing to the complexity of the problem and owing to the changed conditions that result when sorting is introduced. Thus we have examples of differences of opinion even in the same camp, on similar ores, as to the advantages to be gained by sorting. In the South African gold fields some mills practice sorting to the limit, while others do little sorting. The same thing is true in the Coeur d'Alene district and elsewhere.

A. W. Allen[2] has discussed this question from the general viewpoint and along the following lines: (1) relative value of the hand-sorted ore as compared with that of mill concentrates; (2) relative value of hand-sorted waste as compared with that of mill tailings; (3) cost of labor; (4) losses of values in milling, especially with very friable ores; (5) the personal element or variable efficiency of the ore sorter as compared with the impersonal work and constant efficiency of a concentrating machine; (6) the occurrence of special cases where an injurious element is to be removed, as, for example, clay in certain leaching operations; (7) increased mill capacity and reduced wear and tear from sorting out waste; or in case the mine tonnage is constant the mill tonnage is reduced and the efficiency of the mill increased, although the milling cost per ton

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **17**, 214; **18**, 65, 138, 185, 218 (1918). *Min. Sci. Press*, **116**, 622 (1918).
[2] *Eng. Min. Jour.*, **106**, 935 (1918).

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is likewise increased; (8) special forms of sorting where a preliminary process makes partial recovery and aids the final recovery, as, for example, amalgamation before cyaniding; (9) sorting for the removal of foreign material, such as tramp iron (by magnets), wood, paper, sacking and all sorts of debris.

The saving by sorting has been worked out mathematically by G. Luna[1] and is expressed by either of the two following formulas:

$$(1) \quad (A - C)\,V - P - \frac{0.01CVN}{1-0.01N} - \frac{0.01NM}{1-0.01N}$$

$$(2) \quad \frac{0.01\,(M-BV)N}{1-0.01N} - P$$

where C and A are the grade of the ore before and after sorting respectively, B is the grade of the rejected material, N is the percentage rejected of the weight of unsorted ore, M is the milling or smelting charges, including loss in tailings, V is the current price of the metal exploited, and P is the cost of sorting per ton of sorted ore.

The Bunker Hill and Sullivan mill in the Coeur d'Alene district of Idaho is an example of where hand sorting of waste and shipping ore from mine ore carrying lead and silver was formerly practised, but where it has been discarded after demonstration that it was uneconomical. The main factors here were cost of treatment, recovery, and net value of the product. Detailed figures have been supplied by R. S. Handy.[2] A typical Coeur d'Alene ore-sorting plant receiving 800 tons of ore removes 150 tons of waste and 50 tons of high-grade shipping ore at a cost of 65 cts. per ton sorted, or 16 cts. per ton of original ore. The cost of crushing this same ore for concentration is only 3 cts. per ton of original ore. Furthermore it has been found that the loss from crushing and concentrating the high-grade material is very small. Again high-grade sorted ore assays only 45 per cent. lead and 16 oz. of silver per ton, while the mill concentrates can be readily brought up to a 60- or even 70-per cent. grade, which means less expense for freight and smelting charges. Compared with the shipment of 45-per cent. material direct to the smelter, the same smelter return is obtained if this same material is milled up to a concentrate assaying 60 per cent. lead and 21 oz. of silver, with a recovery of about 94 per cent. of the values and allowing a tailings assay of 8 per cent. lead and 3 oz. of silver per ton. A tailings assay of less than 2 per cent. lead is obtainable, which thus demonstrates the economic disadvantage of hand sorting.

Not all of the Coeur d'Alene mills agree on this point, as is evidenced

[1] *Eng. Min. Jour.*, **105**, 1178 (1918).
[2] *Bull. Am. Inst. Min. Eng.*, **136**, 913 (1918); *Trans.*, **61**. *Chem. Met. Eng.*, **19**, 282 (1918). *Min. Sci. Press*, **116**, 855 (1918).

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by the Hecla mill, which practices extensive sorting and believes fully in its economy. Incidentally, it illustrates an instance of where a remote factor may have considerable bearing on the subject, since here the sorting plant is depended upon to produce waste which is very necessary for mine filling.

An example of where sorting is believed to be the only means of averting financial loss is the Alaska-Juneau mill. The milling problem there and the bearing of sorting on its solution will be found later in this article under "Examples of Practice."

Jigs.—The Neill jig, used on California gold dredges, has shown its adaptability to the recovery of tin ore on dredges operating in tin-bearing gravel in Bolivia. Details of results are reported by L. H. Eddy.[1]

Tables.—Jerking tables of the riffled type are still standard for treating sands. The most common forms are the Wilfley, Butchart and Deister, and each form has its adherents among mill men. The Deister-Overstrom and the Deister Plat-O tables are believed by many to have the advantage of spreading the mineral out in a wider fan, and thus of giving better results on fine material or on very low-grade material where the streak of concentrates is very narrow. The Overstrom Universal table is another new table which has been well received. It has legs of wood and is operated by an overbalanced pulley.

Vanners.—Vanners do not appear to be regaining any favor in the mills after having been so hard hit by the advent of flotation. Undoubtedly they can make a closer saving than jerking tables when handling an unclassified feed, or where the values are difficult to recover. This has been demonstrated by A. McLaren,[2] who gives figures to show a material saving by Senn Pan-motion vanners following riffled tables treating a gold-silver ore. However, the general feeling among mill men is that as long as flotation must be used for slimes, its use may just as well be extended to include all the values that escape into the riffled table tailings.

Two belt-cleaning devices for removing concentrates from vanner belts have been described.[3] Each consists essentially of a roll or combination of brush and roll in contact with the vanner belt below the vanner head roll.

A shaking or vibrating table for slimes has been devised by W. McDermott.[4] This combines the high efficiency of a belt-vanner with the simplicity and high capacity of a common Cornish fixed inclined table or rag frame.

[1] *Eng. Min. Jour.*, **106**, 78 (1918).
[2] *Eng. Min. Jour.*, **106**, 11 (1918).
[3] *Eng. Min. Jour.*, **106**, 713, 1040 (1918).
[4] *Min. Mag.*, **19**, 176, 222 (1918).

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AMALGAMATION, MAGNETIC, ELECTROSTATIC, PNEUMATIC AND HEAVY-SOLUTION PROCESSES

Amalgamation.—Although there is a tendency to discard combined amalgamation and cyaniding for straight cyaniding, there is a lack of unanimity that this step is advisable in all cases. A. W. Allen[1] argues that 100 per cent. of the amalgamable gold in an ore is recoverable by amalgamation, but not by cyanide, and further that not all the gold dissolved by cyanide is recovered owing to the harmful effect of colloids and losses from dissolved gold left in tailings. It may even be economy to take out the rich parts of the gold ore by concentration. In the case of silver ores the advantage of amalgamation is not so marked because here fine grinding is necessary for either amalgamation or cyaniding.

As to whether grinding and amalgamation should be carried on in water or in weak cyanide solution, it can be said that while weak cyanide solution helps amalgamation, still milling in water has the advantage of giving a preliminary wash, thus leaving a neutral pulp for cyaniding, of requiring less cyanide solution to be handled, and of lessening the loss of cyanide both chemically and mechanically. Milling in cyanide solution requires a longer time of treatment.

On the whole, amalgamation and the carrying on of the operation in water instead of in cyanide solution seems to offer advantages where a considerable proportion of the gold is amalgamable and where the physical characteristics of the ore are such that milling in water leaves it in better condition as regards moisture content, alkalinity and colloids for the subsequent cyanide treatment.

The high price and scarcity of mercury in South Africa during the war started an investigation and discussion of mercury losses and of the possibility of substituting greased plates or blanket, canvas or corduroy tables for copper plates. Considerable valuable information was brought out, as will be found by reference to the original discussion, although no substitute was found equal to the amalgamated plate.[2]

Further discussion of amalgamation will be found in the chapter on the metallurgy of gold and silver.

The high price of platinum has turned attention to its recovery on some of the dredges in the west. As is well known, this metal does not amalgamate with mercury alone, but it readily amalgamates with sodium amalgam. It is difficult to apply sodium amalgam, however, because the sodium is decomposed on coming in contact with water and loses all its virtue. A more practical process is to amalgamate in an electrolyte containing 0.05 per cent. copper sulphate and 0.05 per cent. sulphuric

[1] *Met. Chem. Eqn.*, **18**, 515 (1918). *Eng. Min. Jour.*, **106**, 531, 610 (1918).
[2] W. A. Caldecott and others, *Jour. Chem. Met. Min. Soc. So. Afr.*, **18**, 163, 173, 197, 232, 290, 1918). *Min. Mag.*, **18**, 213 (1918). *Eng. Min. Jour.*, **106**, 742, 792, 834, 904 (1918).

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acid. Either mercury alone or zinc amalgam may be used with this electrolyte. The efficacy of this method is based on the fact that a film of copper is deposited on the platinum grains and this copper film attaches the platinum to the mercury. In the case of low-grade material where the amount of electrolyte required would be excessive, concentration either by Neill jigs or jerking tables must first be practised to eliminate as much waste as possible.[1]

Magnetic Concentration.—The greatest development in magnetic concentration has been the experimental work on the Eastern Mesabi finely disseminated magnetite ores. Full details of results are not yet available, but the following brief account will give an idea of what is going on. There exists a very large tonnage of this material so situated as to be easily quarried and transported. It carries from 25 to 30 per cent. iron, which can be recovered in high-grade low-phosphorus concentrates, since the phosphorus is in the gangue. An experimental mill of about 200 tons capacity was built in Duluth in 1916 and has run two and one-half years, handling many thousand tons. It consists of a dry coarse-crushing plant, dry magnetic cobbing plant, wet conical ball mill in closed circuit with Dorr classifier, wet magnetic separators of the Grondal, Davis and other types, Oliver filter and sintering plant. About half the original feed is discarded by the magnetic cobbers at sizes from 2 in. down to ¼ in., as a waste product or tailing. The remaining rough concentrates, about ¼ in. in size and assaying 40 to 50 per cent. iron as magnetite, is ground in ball mills to 100 mesh or finer. The classifier overflow usually goes to Davis magnetic separators, of which several types are in use. This makes a concentrate assaying from 60 to 68 per cent. iron and 0.007 to 0.025 per cent. phosphorus. The tailings loss is very low and the grade of concentrate can be controlled at will. One cargo shipment ran 63.25 per cent. iron and 0.008 per cent. phosphorus. The concentrate is filtered and delivered to a sintering plant of the Dwight-Lloyd or Greenawalt type. In due time a large-scale mill will undoubtedly be built to treat this ore.

In the old line magnetic mills also there is a tendency to investigate the merits of various processes, as is illustrated by the Witherbee Sherman Co. at Mineville, N. Y., which is making an extensive research on both wet and dry magnetic concentration and wet gravity concentration as well, with the view of finding out what process is the most economical, considering not only the milling cost but also the extraction and the grade and value of the concentrate.

The Moose Mountain magnetic mill at Sellwood, Ontario, is also experimenting to perfect its flow-sheet. This mill has to grind to 200

[1] V. J. Zachert, *Min. Sci. Press*, **117**, 489, 681, 819 (1918). *Min. Mag.*, **19**, 333 (1918).

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mesh. Incidentally Dorr thickeners and filters are used which not only remove water, but also help to eliminate phosphorus, since the fine slimes which overflow the thickener and pass through the loose filter cloth are mostly gangue and comparatively high in phosphorus.

New forms of magnetic separators have been put on the market by the Magnetic Manufacturing Co. of Milwaukee. For weakly magnetic material their high-intensity separator has a C-shaped magnet with only one air gap, thus obtaining a very high strength of field. Ordinary magnetic pulleys are made capable of receiving more windings and increased strength by having an open interior with a large radiating surface to avoid overheating. One form of magnetic pulley is designed to run on alternating current and thus avoid the necessity of installing generators or motor-generator sets for direct current where only alternating current is available.

A practical chart for use on Wetherill magnets has been published by G. J. Young.[1] This gives the relation of weight of the ore fed, the weight of concentrates produced and the speed and width of the belt.

Pneumatic Concentration.—A dry-process plant is reported to have been installed at Yellville in the north Arkansas zinc and lead district.[2] It consists of a gyratory breaker, rotary drier, two sets of 27-in. rolls. a de-duster using rising currents of air to separate out the dust, one gravity screen, three vibrating screens, a screenless sizing table, and three Sutton-Steele dry concentrating tables, with the necessary fans, bins, conveyors and power plant.

Heavy-solution Process.—Some adverse comment has appeared as to the Chance process of separation by the density method,[3] and the opinion has been expressed that it is really nothing new and furthermore will be found to have a very limited application. The writers of this article nevertheless are not convinced that the process may not have a broad future. It is understood that on account of the war the inventor has had very little opportunity to push it commercially during the past year. A commercial machine for washing anthracite coal has been constructed and is ready to operate; also quartz and feldspar have been floated experimentally, using fluid masses of magnetite and water and galena and water, and chalcopyrite has been held up in a galena-water fluid mass.

An invention along the same line as the Chance process is disclosed in U. S. Patents 1290515 and 1290516 to H. R. Conklin. This patent does away with the necessity of using agitation to maintain the sand-water separating mixture, in that it substitutes finely ground material which will remain in suspension in water for a considerable period.

[1] *Eng. Min. Jour.*, **106**, 868 (1918).
[2] T. Shiras, *Eng. Min. Jour.*, **106**, 909 (1918).
[3] *Coal Age*, **13**, 866, 884 (1918). *Min. Sci. Press*, **116**, 343 (1918).

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Flotation

General.—Flotation has had a steady growth, with the main advance in development of technique and but little gain in knowledge of fundamental theory. Litigation still pends. Development of machines using combined pneumatic and mechanical agitation, of the X-cake and Xylidin reagents and of porous-cell bottoms are important steps in advance.

Application.—Flotation is well established as a supplementary process for sulphide slimes, but its position as a primary process is not so secure. There is, however, a tendency to increase fine grinding and to send a greater proportion of the mill feed to flotation.

Where an ore has to be largely crushed to flotation size to free the mineral, or where all mill tailings are crushed to flotation size before going to waste, there would appear to be no need of installing tables unless a material increase in extraction is obtainable by their use.

In the Inspiration mill where flotation tails are classified and the sands sent to tables, the tables are a necessity, as indicated by the average figures for 1918, which show that of the total copper 62.28 per cent. goes into flotation concentrates, 17.71 per cent. into the slime tailings, 9.99 per cent. into the table concentrates and 10.02 per cent. into the table tailings. Of the copper in the feed to the tables, 49.92 per cent. is recovered on the tables.

As long as flotation continues to give erratic results there will always be the argument for tables to follow flotation and act as a guard. Combination of tables and flotation, even on relatively high-grade ores, seems to represent the tendency in milling and has the advantage of simplicity. New concentrating plants at Bisbee and Ajo in Arizona, which are expected to be the last word in concentrating copper ores, are expected to be along this line.

An example of the importance of adjusting the mill flow-sheet for best flotation results is shown by the Burro Mountain mill. Formerly the mill feed was ¼ to ½ in. from the crushing plant and the sulphides in this, lying in the fine-ore bin, became tarnished so that on a feed assaying 2 per cent. copper the extraction was 72 to 74 per cent. by combined tables and flotation. Now the preliminary crushing in a No. 8 Telsmith gyratory breaker to 4 in., followed by two Symons horizontal disc crushers, gives 10 per cent. coarser than 1 in. and only 6 to 10 per cent. finer than 100 mesh. The primary ball mills take this feed and grind it to 14 mesh in an oil solution, the product going to Butchart roughing tables making concentrates to smelter and tails to Dorr classifier. Classifier slimes go to flotation while the sands go to Marathon mills in closed circuit with Dorr classifiers. The classifier slimes go to flotation.

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Pneumatic cells are used and the flotation tails finally pass over Deister Plat-O tables.

This new process increases the mill extraction up to 83 to 89 per cent., a gain of 10 to 15 per cent., but the main point is that the extraction by the flotation part of the operation has increased from 46 up to 70 per cent., all due to the rearrangement of the crushing and grinding.

In regard to arrangement of cells, all sorts of combinations are in use, of roughing cells, cleaning cells, recleaning cells, etc., and in many cases with concentrating tables before or after the cells or in closed circuit with the cells. Some of these flow sheets have been given by A. Del Mar.[1]

Practically all mills now clean all or part of the concentrates by some method of rerunning through cells again. The advantage of this has been demonstrated at the Kennecott mill, which formerly did not clean the rougher concentrates. The cleaning is found to eliminate a large proportion of the fine insoluble gangue without any reduction of mill extraction.

A unique method of cleaning the froth used in some mills on pneumatic cells is to restrict the froth overflow to a short space at the center of the cell. This space is divided off from the two end sections by cross baffles extending down through the froth to about the surface of the liquid. The froth rising in the two end sections does not discharge, but is subjected to powerful water sprays playing downward just at the baffles. These sprays thus force the froth down under the baffles and into the center compartment and, in so doing, considerable insoluble is washed out of the froth. In one case on a slimy ore, concentrates formerly running 10 per cent. copper were raised to 26 per cent. by this device.

Milling of quicksilver ores on tables has been practised in California, but generally abandoned on account of high slime losses. Flotation should avoid this. In fact, at Black Butte, Ore., a flotation plant has been operating very successfully on low-grade quicksilver ores.

On native sulphur ores, too low-grade for liquation, flotation has been shown by experiment to be capable of making good recoveries in a high-grade concentrate, but no commercial application of the process has yet been made.[2]

In Michigan, the experimental plant of the Calumet and Hecla Co. has fully demonstrated the feasibility of an economic recovery of fine native copper from not only the present conglomerate tailings but also the old tailings dumps, and a large-scale flotation plant is under construction. Other companies having tailings rich enough to warrant treatment will undoubtedly follow suit later.

[1] *Min. Sci. Press*, **116**, 221; **117**, 311 (1918).

[2] *Eng. Min. Jour.*, **106**, 657 (1918).

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On graphite ores, both in Alabama and New York, flotation is finding extensive application. A typical mill-scheme involves comparatively coarse crushing to 14 mesh in rolls, followed by hydraulic classifier the spigot of which is discarded as waste, while the overflow is floated in Callow rougher and cleaner cells. This first float is reground in pebble mills and again floated in a second set of rougher and cleaner cells to get a high-grade product.

Gold and Silver Ores.—Flotation of gold and silver ores as compared to cyanidation still remains a subject of discussion. G. H. Clevenger[1] has compared the two processes from the viewpoint of respective losses, net value of products, costs, and the treatment and marketing of the products, and leads to the conclusion that the final decision rests on the conditions in any one district. Flotation is not practised at Porcupine, at Tonopah or at Goldfield, except that one plant at Goldfield, which at one time adopted flotation, has now given it up for cyaniding except where the ore carries considerable copper. At Cripple Creek one company uses flotation while another company which tried flotation reverted back to combined gravity concentration and cyaniding. At Cobalt flotation is extensively used and appears to be on the increase, but even there the Nipissing company has discarded its flotation plant and gone back to cyaniding, chiefly on account of the difficulty of treating or marketing the flotation concentrates.

Experiments in the Amparo mill, at Etzatlan, Mexico, showed that with normal prices for reagents there was no advantage in changing from cyaniding to flotation. Details of the tests and calculations in this case are reported by E. J. Atckison.[2]

Oxidized Ores.—Not much advance is reported in the treatment of oxidized ores. The Miami experimental plant for treating combined carbonate and sulphide copper minerals is trying out a process in which the sulphides are first floated in the regular way and then the residue is conducted through a long wooden barrel where it meets a sulphur-dioxide gas which enters the lower trunnion and passes out at the upper where the pulp is fed. This gas changes the carbonates and silicates into sulphates and the pulp then goes to a tumbling barrel containing scrap iron together with a certain number of manganoid cast-iron balls. The copper is here reduced to metallic form, in which condition it is floated in a second series of cells below the tumbling barrel.

The work of the U. S. Bureau of Mines on filming lead carbonate ores, summarized in MINERAL INDUSTRY, **25**, 205, has now been published in complete detail.[3]

[1] *Eng. Min. Jour.*, **105**, 743 (1918).
[2] *Min. Sci. Press*, **116**, 575, 677 (1918). See also under "Flotation." in the chapter on the metallurgy of gold and silver.
[3] D. A. Lyon and O. C. Ralston, *U. S. Bureau of Mines Bulletin*, **157** (1918).

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This problem of the efficient treatment of low-grade mixed sulphide and oxidized copper ores is a very important one, and is by no means solved. The patent of R. Gahl on the use of limestone for recovering copper from dilute solutions may be found to have an application in solving this problem; this is also true of his patent for roasting and leaching of granular flotation middlings and tailings.

Preferential Flotation.—This is practised to considerable extent, although much is to be desired in the way of improvement.

The Terry differential flotation process[1] depends on the action of solutions containing 0.04 to 0.06 per cent. ammonia, which form oxides on iron sulphides, but brighten sulphides of zinc, copper, and lead. The latter are thus easily floated while the oxidized iron sulphides sink. Some results of tests show very good separation. For best work, pneumatic cells and wood oils should be used.

At the Kennecott mill more or less selective action takes place between the chalcopyrite and the pyrrhotite, but as none of the pyrrhotite appears to be entirely free from copper it is impossible to obtain a high-grade concentrate and a high recovery simultaneously, and the results grow poorer as the iron in the ore increases. The ore runs 2 per cent. copper and when the iron is not over 12 per cent. the concentrates will run 14.5 per cent. copper, 33 per cent. iron and 7 per cent. insoluble, and the extraction is 83 per cent.; but if the iron goes up to 15 per cent., the concentrates assay 13 per cent. copper, 35 per cent. iron and 7 per cent. insoluble, and the extraction drops to 76 per cent.

The selective flotation of chalcopyrite by means of electrolytes alone is referred to later.

For differential flotation of lead and zinc at the Morning mill in the Coeur d'Alene district, Callow cells are used. The pulp goes first through two lead roughing cells in series, the froth from both cells being cleaned in a cleaner cell. The tails of the cleaner cell go back to the Pachuca agitators at the head of the first lead rougher cell. The tails from the second lead rougher cell are divided between two units of zinc cells, each unit consisting of Pachuca agitator and two roughing and one cleaner cell, arranged and operated in just the same way as the lead unit. No. 2 Cleveland Cliffs oil is used in the lead cells and No. 8 G. N. S. or No. 350 Pensacola in the zinc cells.[2]

At another mill[3] in the same district, working on an old lead-zinc tailings dump, the material has become somewhat oxidized so that sodium sulphide has to be used occasionally to form a sulphide film. Here the lead is first floated in a K. and K. machine using a small amount of No.

[1] *Min. Sci. Press*, **117**, 533 (1918). *Chem. Met. Eng.*, **19**, 319 (1918).
[2] C. T. Rice, *Eng. Min. Jour.*, **106**, 482 (1918).
[3] *Eng. Min. Jour.*, **106**, 528 (1918).

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5 G. N. S. oil. The froth is kept 14 in. deep and only the top 3 in. is taken off by scrapers, since the bottom part of the froth is more zinky. Tails from the lead machine go to another K. and K. machine, where No. 350 Pensacola and coal-tar oil and a little copper sulphate make a thin shallow zinc froth that overflows continuously. Both the lead and the zinc froth are broken down and treated separately on Deister Overstrom tables. The lead table makes lead concentrates assaying 70 to 75 per cent. lead and 3 per cent. zinc, and a zinc product assaying 40 per cent. zinc and 10 per cent. lead. The slimes assaying 30 per cent. lead and 12 per cent. zinc go with the lead concentrates. The zinc table makes a little band of lead concentrates assaying 60 per cent. lead and 3 per cent. zinc and a broad band of zinc product assaying 35 per cent. zinc and 12 per cent. lead.

It appears that on Coeur d'Alene ores the gentle action of a pneumatic cell or a K. and K. cell is more favorable for separating the lead and zinc than the violent action of mechanical agitation.

A general discussion of the Coeur d'Alene practice, including the conditions and adjustments that make for the best separation between the lead and the zinc, has been given by W. L. Zeigler,[1] and a somewhat similar discussion covering differential flotation of lead and zinc in general by A. Del Mar.[2]

Selective flotation of lead and zinc is a part of the flow sheet of the Sunnyside mill at Eureka, Colo., treating a complex ore containing gold, silver, lead, zinc and copper.

At Broken Hill, Australia, the Bradford sulphur-dioxide process has been in operation since 1917, yielding lead concentrates assaying 61.6 per cent. lead and 83.2 oz. of silver, and zinc concentrates assaying 49.54 per cent. zinc, 4.34 per cent. lead and 14.47 oz. of silver per ton. This process at the Broken Hill Proprietary mill formerly emulsified with niter cake instead of oil, but now no emulsifying agent whatever is used. In adding the sulphur-dioxide gas in acidulated solution, both the galena and blende become thoroughly wetted and sink; but under the condition of violent mechanical agitation the galena soon comes to the surface, while the zinc stays down, being kept wetted by the action of the gas, to which it is more susceptible than the galena. Pyrite, when present, comes up with the galena. The zinc can be floated later by elimination of the sulphur dioxide or by giving it a regular flotation treatment in separate zinc cells.

Full details of the operation in Australia have been supplied by G. C. Riddell[3] and also by E. T. Henderson,[4] who likewise has covered the

[1] *Eng. Min. Jour.*, **105**, 741 (1918).
[2] *Min. Sci. Press*, **117**, 691 (1918).
[3] *Chem. Met. Eng.*, **19**, 822 (1918). *Eng. Min. Jour.*, **105**, 739 (1918).
[4] *Min. Sci. Press*, **117**, 375, 404, 407 (1918).

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Horwood roasting process and an earlier Bradford process using salt and sulphuric acid.

A case is reported where a preferential separation of galena and pyrite was effected experimentally by first floating the lead in an alkaline solution and then floating the iron in an acid solution.

In floating Canadian molybdenite the problem is to handle a flaky mineral associated with pyrite, and has been worked out by Callow cells and Callow screens. At the Quyon plant the feed contains 0.65 per cent. molybdenum sulphide, the concentrates 93 per cent. and the tailings 0.03 per cent., thus giving an extraction of 95 per cent. Kerosene is the best oil and about 1.2 lb. per ton is mixed with about 0.2 lb. of pine oil. The main features of the process are coarse crushing in gyratory breakers followed by Marcy mill, in closed circuit with Dorr classifiers, to 48 mesh. The pulp then goes to Callow rougher cell making waste tailings and froth to cleaner cell. Froth from the cleaner cell goes to 150-mesh Callow belt screen, where oversize is high-grade molybdenite and undersize is molybdenite, pyrite and gangue which joins the cleaner-cell tails, going back to be fed again to the rougher cell.

In the deposit at Climax, Colo., the molybdenite is amorphous and associated with pyrite, so that a straight selective flotation of the molybdenite from the pyrite is required. This is accomplished by using four rougher Janney cells followed by a fifth Janney for partial cleaning of the rough concentrates. The concentrates from the Janney cleaner pass to three Callow cells in series, each receiving froth from the preceding. A vanner is being installed further to remove pyrite from the concentrates. Details of this mill and results are given by D. F. Haley.[1]

Machines.—Millmen appear to be conservative in sticking to standard types of machines, although each year sees modifications and improvements. In addition, new machines come forth continually to be tried out in practice and to survive and grow in use or to pass into oblivion according to their merit.

The standard Minerals Separation machine is now designed to be operated with a low pulp level and the rate of pulp circulation has been increased to a point where it is faster than the rate of discharge and openings are provided for the excess to flow back into preceding compartments of the spitzkasten.

The Ruth flotation machine, which has demonstrated its merit, has been described by J. P. Ruth, Jr.,[2] and A. J. Hoskin.[3] It resembles the Minerals Separation machine in having an agitating compartment and a

[1] *Bull. Am. Inst. Min. Eng.*, **140**, 1183 (1918); *Trans.*, **61**. *Eng. Min. Jour.*, **106**, 394 (1918). *Min. Jour.*, **122**, 537 (1918).
[2] *Eng. Min. Jour.*, **105**, 752 (1918).
[3] *Min. Sci. Press*, **117**, 119 (1918).

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spitzkasten, but its shaft is hollow, thus permitting air to be sucked down and delivered to the pulp through three radial openings in the impeller. This machine is also made in laboratory testing size by the Mine and Smelter Supply Co.

The Janney machine is made in two forms, one the older mechanical agitation form and the other the newer mechanical air form. In the latter the pulp from the central agitating chamber overflows to the two side spitzkasten, which are supplied with an inclined submerged porous cloth bottom up through which air rises to assist the frothing. The froth overflows the spitzkasten in the usual manner, while the tailings pass out to the next cell. This machine is most successful and has been

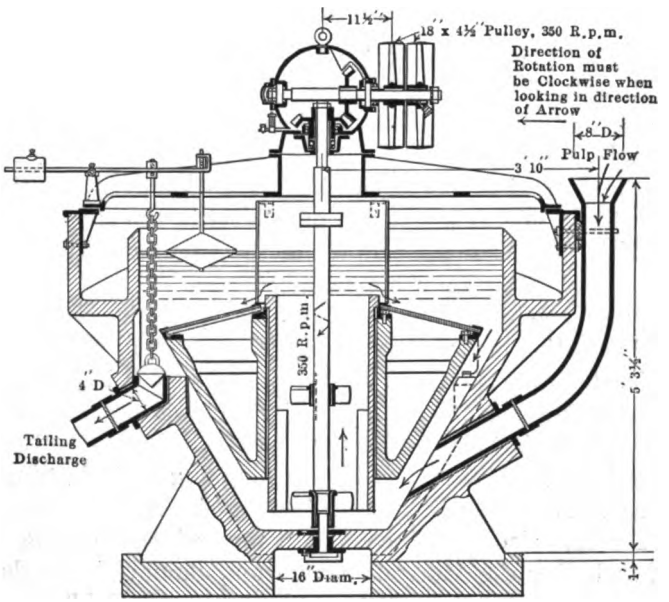

FIG. 2.—Cross-section of Jones-Belmont flotation machine.

adopted by the Utah Copper Co. to remedy the irregular results and non-uniform action obtained with the Janney mechanical agitation cells or pneumatic cells when working alone.

The Little Janney machine resembles the second type of the preceding, but is made small for small-capacity mills and has only one spitzkasten or air compartment. In this form part of the tailings are returned to the bottom of the central agitating compartment and part pass out of the machine.[1]

The Jones-Belmont machine used at Tonopah, Nev.,[2] combines me-

[1] *Eng. Min. Jour.*, **106**, 497 (1918).

[2] *Eng. Min. Jour.*, **106**, 497 (1918).

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chanical and pneumatic agitation. Its action is clearly shown in the figure. Pulp is fed at the right, entering in the annular space between the two concentric 60° cones. The impeller in the central cylinder, 18 in. in diameter, beats and lifts the pulp which, as shown by the arrows, overflows the top of the cylinder and moves radially outward over the inclined annular porous cloth cover of the inner cone, 5 ft. in diameter. Here air comes up through the pulp, which is about 12 in. deep over the cloth. Froth overflows into the annular launder while the tails circulate down again between the cones, part of the tails finding their exit through the automatically regulated valve shown at the left.

The Rork-Butchart horizontal machine is practically the same in principle and operation as the Kraut and Kohlberg described in previous reviews.

A new form of the Kraut-Kohlberg machine removes the side spitzkasten and replaces it with a froth collecting chamber above. This is claimed to be an advantage over the older form.[1]

The Zeigler machine, used somewhat in the Coeur d'Alene district, resembles the original K. and K. machine except that the agitating chamber, while at one side, is above the pulp level in the spitzkasten and a compressed-air lift raises the pulp from the bottom of the spitzkasten up to the bottom of the agitating chamber.

The Hynes machine, used at Guanajuato, Mexico, is a horizontal mechanical agitation machine consisting of a trough in which are a number of perforated discs, 30 in. in diameter, and spaced 1¼ in. apart on a horizontal shaft making 100 r.p.m. Only the lower portions of the discs are submerged, so that the perforations carry air down into the pulp.[2]

A laboratory apparatus, combining roughing and cleaning cells of the pneumatic type, has been described by A. W. Fahrenwald.[3] The same author has also described and compared the leading types of machines, including the Minerals Separation, Janney, Minerals Separation sub-aeration, Janney mechanical-air, Kraut-Kohlberg, Callow, Flinn-Towne, Cole-Bergman, Inspiration, and launder and cascade types.[4]

A great variety of modifications of the Callow cell have been evolved in the Coeur d'Alene mills.[5]

The use of sectional cast-iron bottom-pans for Callow cells is now almost universal. The type of such pan adopted in the Coeur d'Alene district has been described.[6]

For Callow cell bottoms, loosely woven canvas quilting in several

[1] *Eng. Min. Jour.*, **105**, 746 (1918).
[2] *Eng. Min. Jour.*, **107**, 97 (1919). B. R. Bates, *Min. Sci. Press*, **117**, 277 (1918).
[3] *Met. Chem. Eng.*, **18**, 487 (1918).
[4] *Chem. Met. Eng.*, **19**, 77, 129 (1918).
[5] C. T. Rice, *Eng. Min. Jour.*, **105**, 707 (1918).
[6] *Eng. Min. Jour.*, **105**, 734 (1918).

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layers is most common. The Ray Consolidated Co. has made very satisfactory bottoms 3 in. thick, using sand screened through 10 on 30 mesh and mixed with about 16 per cent. of Portland cement. Iron reinforcing rods ¼ in. in diameter are used. A similar but much stronger bottom has been developed by J. M. Callow, using bakelite as a binder for the sand. These bottoms show 27 to 30 per cent. of voids.

Trouble from blinding of these bottoms has been traced to iron rust from ball-mill grinding, and the remedy is a hydrochloric-acid wash. This has led to the belief that the principal cause of trouble with cloth bottoms is metallic iron and that the remedy is to remove metallic iron from the pulp by magnets. Further confirmatory evidence is that much less trouble with bottoms occurs when pebble mills are used for grinding.

On Callow cells at the Bunker Hill and Sullivan mill the siderite in the ore tended to rust the cloth bottoms. This difficulty was overcome by using quilted mats, the top surfaces of which are impregnated with rubber. A further advantage of this rubber surface is that wood pulp does not stick to it as it does to plain canvas.[1]

G. Crerar[2] has supplied instructions for starting and operating pneumatic cells, including the adjustment of the air and oil and the effects produced on the froth by too much or too little oil or too much air.

A form of cascade machine, making use of Pohle air lift for circulating the pulp, has been devised by W. A. Fahrenwald.[3] Also various forms of machines in practical use, which apply the cascade principle, have been described and discussed by H. H. Smith.[4]

Potter-Delprat Process.—This process, not being used in the United States, is not familiar to our millmen and they therefore should welcome the very comprehensive article by E. T. Henderson[5] on its application in Australia.

Oils.—Little change is noted in the use of standard flotation oils. The use of oil vapor to avoid the Minerals Separation patent is reported to have been successful at the Ray Consolidated mill and elsewhere. This oil-vapor process is covered in the patent application of Walter A. Scott.

The Callow reagents, X-cake and Xylidin, are being used very satisfactorily in many plants in the Southwest. Although high in price, the small quantities required makes them commercially economical. In using X-cake the Magma Copper Co. dissolves it in hot water at a ratio of about 600 to 1. At this plant the use of X-cake has increased the filtering and settling rate of the concentrates some six times. Most

[1] *Eng. Min. Jour.*, **106**, 257 (1918).
[2] *Eng. Min. Jour.*, **106**, 878 (1918).
[3] *Min. Sci. Press*, **117**, 87 (1918).
[4] *Min. Sci. Press*, **116**, 505 (1918). *Min. Mag.*, **18**, 316 (1918).
[5] *Min. Sci. Press*, **117**, 375 (1918).

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plants however prefer to use Xylidin as a solvent for X-cake and feed the solution in the regular feeders formerly used for oil. The present price of X-cake is 25 cts. per lb. at factory, and of the mixture, 31 cts. per lb. These reagents require a neutral or slightly alkaline circuit and no pre-agitation is necessary in using them in Callow cells.

The mill of the Consolidated Coppermines Co. at Kimberly, Nev., uses an alkaline circuit, and during the earlier part of 1918 employed a mixture of coal tar, coal-tar creosote, and No. 80 Pensacola pine oil, while in the latter part of the year X-cake and Xylidin were substituted. The following table gives comparative results.

	Coal Tar Reagents.			X-cake and Xylidin.		
	Per Cent., Copper.	Per Cent., Silica.	Per Cent., Iron.	Per Cent., Copper.	Per Cent., Silica.	Per Cent., Iron.
Feed	1.186	87.10	3.50	1.336	85.90	3.70
Concentrate	13.623	27.30	20.90	18.330	13.50	27.60
Tails	0.277	91.50	2.20	0.206	90.10	2.10
Extraction	78.22	2.14	40.84	82.310	0.97	46.61
Ratio of concentration	14.68 into 1			17.00 into 1		
Water in concentrate, per cent	17.15			9.39		
Cost of reagents	7.46 cts. per ton			15.6 cts. per ton		

Notwithstanding the higher cost per ton for X-cake and Xylidin their use is more economical because they yield not only higher extraction, but also a higher-grade concentrate, more free from colloids and with less moisture after filtering, which lessens the tonnage and expense of filtering, shipping and smelting. The amount of the flotation mixture (X-cake and Xylidin) does not exceed 0.25 lb. per ton of ore.

At the Arizona Copper Co.'s mill the extra copper recovered by using these reagents amounted to 3.46 lb. per ton, which, figured at 15 cts. per lb., is 51.9 cts. per ton, while the entire extra cost was only 23.7 cts. per ton.

For feeding oil uniformly the well-known disc type of feeder is perhaps most used. For light oils an ordinary vessel and cock is satisfactory. In the Coeur d'Alene district this is modified so that water or heavy brine solution is dripped and delivered to the bottom of a vessel having oil floating on the water or brine. As the water or brine comes in, the oil rises and overflows uniformly through the discharge outlet. Another device consists of a special form of cam-driven plunger pump with ball valves. Still another is a revolving hub with bent wire spokes. The spokes dip into an oil bath and then carry up oil in their revolution until the oil falls off at a point when the end of the spoke is in such a position that the oil drops outside the tank.[1]

[1] C. T. Rice, *Eng. Min. Jour.*, **106**, 1022 (1918).

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Reagents.—The investigation by M. H. Thornberry and H. T. Mann on the effect of small amounts of addition agents in floating Missouri lead slime, referred to in MINERAL INDUSTRY, **26**, 800, has been continued and the general conclusion is that on this particular material and with the special oils used, in very few tests was any benefit shown, but, on the contrary, detriment usually results when chlorides, sulphates, hydroxides or nitrates are added to flotation pulp.[1]

That this conclusion should not be too generally adopted for all ores is pointed out by C. A. Wright and J. G. Parmelee,[2] who cite the beneficial use of alkaline chlorides on some ores. The value of alkaline chlorides for flotation has also been reported in previous years as, for example, in the Lyster and Bradford processes for selective flotation of blende and pyrite.

At Guanajuato, Mexico, trouble with acid mine water for milling, carrying iron oxide and sulphate, is remedied to a certain extent by lime, but if lime is used in excess the extraction drops. Soda ash will precipitate the excess of lime, but it is an expensive reagent.[3] Excess of lime in solution may be counterbalanced by adding soluble sulphur compounds, such as sodium or calcium sulphide, with beneficial results.

The mill of the Utah Leasing Co., on an old tailings dump carrying copper and iron sulphides, first used acid unsuccessfully, then changed to neutral pulp with better results, and finally adopted alkaline circuit, obtained by adding to the ball mill 10 lb. of soda ash per ton of ore along with 0.7 lb. of an oil mixture of 85 per cent. coal tar and 15 per cent. coal-tar creosote. A little crude turpentine is also added in the Minerals Separation cells.

The effect of colloids and gangue in flotation is referred to later under "Theory." Strictly speaking, these are not addition agents, but their action appears to be in the same category as that of addition agents.

Many of the troubles in operating flotation plants may be due to the oils and reagents as pointed out by Ralston,[4] who indicates over-oiling and the deadening effect of raw oil on the froth as perhaps the most common. Other detrimental agents are strong brines, excessive acid, iron or copper sulphates (remedied by lime or a little cyanide), lubricating oils, tannin, glue and other organic agents, cement, fine clay, etc. Flotation oils may deteriorate and lose volatile constituents on standing open. Tough froth is a trouble due to improper oil mixture, and fluctuating feed may give poor results.

[1] *Bull. Mo. Sch. Mines*, **4**, No. 2, 1917. *Eng. Min. Jour.*, **105**, 915 (1918). *Met. Chem. Eng.*, **18**, 71, 249 (1918).
[2] *Min. Sci. Press*, **116**, 641 (1918).
[3] B. R. Bates, *Min. Sci. Press*, **117**, 277 (1918).
[4] *Eng. Min. Jour.*, **105**, 735 (1918).

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On the other hand, small amounts of acid, alkali, copper sulphate or cyanide are beneficial in certain cases.

A most remarkable result is reported in the use of ordinary weak salt solution, or even sea water alone, for floating chalcopyrite away from pyrite and pyrrhotite.[1] High-grade concentrates are produced and low tailings. Further experiment has shown that other electrolytes such as various salts of sodium, magnesium, ammonium, and calcium give somewhat similar results, but chlorides are the best. A few tests on other ores than chalcopyrite have not shown such good results. However, the development of this process is understood to have been disappointing and not to have come up to earlier expectations.

Handling Concentrates.—The breaking down of flotation froth with water spray, thickening in Dorr tanks, and filtering in Oliver filters is now pretty well standardized. Details of the apparatus in the Utah Leasing Co.'s plant have been given by H. H. Adams,[2] and a rather novel scheme for handling zinc flotation concentrates carrying a little lead has been reported by A. Del Mar.[3] The latter involves the use of a receiving tank, a centrifugal pump, a Wilfley table for removing lead, and a Dorr thickener.

Some of the remedies for troubles in operation of Oliver filters have been given by C. T. Rice,[4] and some improvements on the Oliver filter have been made by John A. Rothwell, as follows: (1) The pipes are so arranged that none of the water sucked out can be blown back into the cake when the blow comes. (2) A shallow tank is used with a mechanically operated rake to scrape the solids down the sides, in the place of agitation by air-jets or paddles. (3) A pinion-gear drive is substituted for the former more complicated gearing. (4) The scraper for concentrates is vertical and is placed somewhat below the level of the center of the drum.

A new type of suction filter, known as the American Disc type, is coming into use for flotation concentrates. It resembles the Oliver filter in design and operation, except that the drum is replaced by several suction discs on a horizontal shaft and the cake attaches to both sides of each disc. The rear part of the tank is common for all of the discs, but the front half, where the cake is discharged, has re-entrant spaces to give opportunity for the cake to fall down into a proper receptacle below. This filter appears to have great merit, especially in that it has a high capacity and occupies minimum floor space.

An improvised drier for flotation concentrates, described by S. P.

[1] *Min. Sci. Press*, **116**, 167 (1918).
[2] *Eng. Min. Jour.*, **105**, 724 (1918).
[3] *Eng. Min. Jour.*, **105**, 1177 (1918).
[4] *Eng. Min. Jour.*, **106**, 899 (1918).

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Lindau and W. E. Evans,[1] consists merely of an old pan conveyor heated by oil burners and having improvised rakes to break up the cake. The cost for oil amounts to around $1 per ton dried, which is rather high as compared with 25 cts. for the Lowden drier.

When freight on concentrates is a big factor it may be worth while to roast off the sulphur before shipment. Experiments at the Kennecott mill show that the weight can be reduced 15 to 18 per cent. in this way, thus saving freight and smelter charges and at practically no expense, since oil is now used to dry the filter cake before shipment.

Theory of Flotation.—There is as yet no universal agreement on the fundamental theory of flotation. Contributions along this line have been submitted during the past year by J. A. Block and others on the theory of electric charges,[2] by W. H. Coghill on the measurements of surface tensions,[3] by the same author and C. O. Anderson on a mathematical discussion of surface tension and contact angles,[4] by W. D. Bancroft on the phenomena of adsorption,[5] by F. G. Moses on the action of colloids on adsorption and surface tension, usually to the detriment of flotation,[6] by J. A. Pearce on some harmful effects actually obtained from colloids in flotation of various ores and including description of a machine to reduce this trouble,[7] by G. J. Young on the important assistance to flotation due to the property of flocculation, and also on the action of obscure chemical reactions in causing adherence of oil films,[8] and by J. M. McClave on aid or injury to flotation due to various gangues, as shown by actual tests, which necessitated modifications of oil mixtures in order to counteract the effect of harmful gangues.[9]

The Inspiration ores are good examples to show the effect of gangues on flotation. Some of the ore is granite porphyry and some is schist. The results of two mill runs on rather low-grade material of both types, having the same assay, follows:

	Granite Porphyry.	Schist.
Assay of feed, per cent. total copper	1.05	1.05
Assay of feed, per cent. oxide copper	0.24	0.17
Per cent. on 48 mesh in flotation feed	4.50	3.80
Assay of flotation concentrate, per cent. total copper	30.85	32.27
Assay of table concentrate, per cent. total copper	22.15	7.00
Assay of general concentrate, per cent. total copper	25.42	25.77
Assay of general concentrate, per cent. insoluble	39.20	35.10
Per cent. moisture in filtered concentrate	23.70	18.60
Assay of general tails, per cent. total copper	0.39	0.23
Assay of general tails, per cent. oxide copper	0.20	0.15
Recovery of total copper, per cent	63.84	78.79
Recovery of sulphide copper, per cent	77.13	91.19

[1] *Min. Sci. Press*, **116**, 657, 745 (1918).
[2] *Min. Sci. Press*, **116**, 255, 399 (1918).
[3] *Min. Sci. Press*, **116**, 743, 747 (1918).
[4] *Met. Chem. Eng.*, **18**, 595 (1918). *Jour. Phys. Chem.*, **22**, 237 (1918).
[5] *Eng. Min. Jour.*, **106**, 350 (1918).
[6] *U. S. Bur. Mines Tech. Paper*, **200** (1918). *Chem. Met. Eng.*, **19**, 775 (1918). *Min. Sci. Press* **117**, 730 (1918).
[7] *Min. Sci. Press*, **117**, 491 (1918).
[8] *Eng. Min. Jour.*, **106**, 1127 (1918).
[9] *Eng. Min. Jour.*, **105**, 738 (1918).

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The fundamental theory on which the Ruth machine is based is that the function of oil is not to adhere to sulphides, but to cause the water to become thoroughly diffused with fine air bubbles.[1]

Flotation Litigation, Patents and Royalties.—The progress of flotation litigation in 1918 has been in the direction of further interpretation of the scope of the claims of the main patent, Minerals Separation No. 835120. The points under controversy are being gradually narrowed down and during the year 1918 the discussion has been almost wholly directed to determining what percentages of oil come within the terms of the Supreme Court decision of 1916.

The fundamental points at issue are:

1. Is the upper limit of oil above which there is no infringement and below which there is infringement (*a*) ½ per cent.? (*b*) 1 per cent.? (*c*) over 1 per cent. "where the results obtained are the results obtained by the use of oil in a quantity amounting to a fraction of 1 per cent. on the ore."

2. If the upper limit is the use of 1 per cent. of oil, is this limit fixed irrespective of the nature of the components of the oil or is the use of ⅒ per cent. of an active oil, such as pine oil, mixed with over 1 per cent. of a relatively inert oil, such as kerosene, an infringement when the latter oil is added solely to avoid the terms of the patent?

The Supreme Court in Dec., 1916, in the Butte & Superior case, limited the scope of the patent to a fraction of 1 per cent. of oil without *specifically* stating that *all* fractions of 1 per cent. were infringements. Judge Bourquin in August, 1917, on new evidence and on the basis of a disclaimer filed after the above decision of the Supreme Court, held that the use of over 1 per cent. was an infringement where the results obtained are the same as those with under 1 per cent., and condemned the addition of inert oil as a mere subterfuge. The Court of Appeals for the Ninth Circuit reviewing Judge Bourquin's decision held, May, 1918, that the upper limit for infringement was ½ per cent., irrespective of the nature of the oils used. A writ of certiorari was applied for to enable the Supreme Court to decide exactly where the infringement begins and ends. This application was allowed Nov. 11, 1918, and the case will be heard sometime in 1919.

The natural result of all this litigation has been to stimulate greatly endeavors to avoid the patents of Minerals Separation in other ways than by increasing the percentage of oil. One of the most interesting and promising of these attempts is the use of oil vapor mixed with air. In this connection it should be noted that the claims of the Minerals Separation patent refer to the addition of a specific amount of *liquid* oil,

[1] A. J. Hoskin, *Min. Sci. Press*, 117, 119 (1918).

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in view of which it appears likely that the use of oil *vapor* would not be regarded as an infringement.[1]

In connection with flotation patents an interesting discussion of scientific nominalism and physical phenomena of flotation has been contributed by D. H. Norris.[2]

Closely associated with the flotation litigation is the question of the fairness of the Minerals Separation Co. in its license contract and in its royalty schedule. The terms of the licenses and the royalties have been published,[3] and the reader is referred to the original for information. A form of the contract which the company offers to an inventor of a flotation improvement has also been published.[4] The royalties do not appear to be excessive and the license appears to be fair except as to the binding of the licensee to turn over all improvements to the licensor and the perpetuating of the contract beyond the date of the expiration of the basic patent. The contract which they offer to inventors, however, appears to be distinctly one-sided.

The U. S. Federal Trade Commission has issued a formal complaint against the Minerals Separation Co., charging them with being a German company and with using unfair methods of competition tending toward a monopoly.

In Canada also a government investigation of this company has been under way to determine whether mining interests are being injured. No flotation litigation has been started in Canada up to the present time.

The Canadian laws appear to be more favorable to the miner in a case of this kind than those of the United States, and if the Minerals Separation Co. should attempt practices which can be shown to be unjust, prompt redress can apparently be had through government agency.

Details of Practice.—For further information on flotation plants the reader is referred to articles by H. H. Adams[5] on the Utah Leasing Co.'s mill at Newhouse, Utah; on the Sunnyside mill at Eureka, Utah:[6] by C. T. Rice on flotation in Idaho;[7] by A. H. Jones on flotation at Surf Inlet mines, British Columbia;[8] by G. C. Klug on practice at Broken Hill;[9] by E. T. Henderson likewise on Broken Hill practice.[10]

[1] The decision of the U. S. Supreme Court handed down June 2, 1919, in the Butte & Superior case is that a mechanical agitation process infringes the Minerals Separation patent only when it uses oil in amounts of 1 per cent. or less. This leaves the question still open as to whether the court will decide that the pneumatic cell (Miami case) is an infringement even though less than 1 per cent. of oil is used.

[2] *Min. Sci. Press*, **116**, 161 (1918).

[3] *Min. Sci. Press*, **116**, 236 (1918). *Eng. Min. Jour.*, **105**, 332, 333 (1918).

[4] *Min. Sci. Press*, **116**, 84 (1918).

[5] *Eng. Min. Jour.*, **105**, 535 (1918).

[6] *Eng. Min. Jour.*, **105**, 193 (1918). *Met. Chem. Eng.*, **18**, 170 (1918).

[7] *Eng. Min. Jour.*, **105**, 707; **106**, 482 (1918).

[8] *Eng. Min. Jour.*, **105**, 720 (1918).

[9] *Min. Mag.*, **19**, 243, 298 (1918).

[10] *Min. Sci. Press*, **117**, 375, 404, 407 (1918).

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ACCESSORY APPARATUS

Belt Elevators.—To avoid some of the troubles from elevators the wet elevator in the Elko Prince mill[1] has a concrete boot large enough to retain the contents of the buckets in case of a spill. The lower journals are one-half bearings, mounted in the boot just outside the housing; they are maintained at a constant tension by a counterweight and are hinged on a shaft at the back of the elevator. Slipping of the belt developed as it wore and was eliminated entirely by attaching six steel strips, ½ by $\frac{3}{32}$ in., across the face of the head pulley; the strips do not injure the belt, but, on the contrary, probably increase its life by preventing slippage.

An efficient device for discharging material that tends to stick in elevator buckets has been reported by H. M. Schleicher.[2] It consists of a U-shaped loop of heavy wire having the ends fastened to the belt in such a position that the loop is suspended in the bucket, and as the belt passes around the pulley, the wire describes an arc of a circle in the bucket and loosens the material so that it is easily thrown out.

Another device, described by A. M. Nicholas,[3] for a similar purpose, involves the placing of an eccentric pulley inside the belt on the upcoming side. This pulley is revolved by external power at such a speed as will impart sufficient vibration to the belt to prevent the pulp from from settling and packing in the buckets.

Conveyors.—Of all types of conveyors the belt conveyor is most common in the mills. The reader is referred to a most excellent detailed article by R. S. Lewis,[4] covering the merits, installation, operation, capacities, etc., of this apparatus and also touching upon apron, push, flight, and spiral types.

Launders.—Launders in the Prestea Block A gold mill are lined on the bottom with specially prepared concrete slabs and on the sides with old belting. The stamp launder is 13 by 13 in. with a 10-per cent. fall, and the main launder is 14 by 14 in. with a 6.5-per cent. fall.[5]

Concrete liners for launders are also reported by F. Wartenweiler[6] to be very satisfactory in South African gold mills. For narrow launders U-shaped blocks are used and slabs for wide launders. Another excellent form consists of old tube-mill liner bars set on edge in cement.

Feeders and Distributors.—The combination Ross grizzly and feeder has been described already under "Screens."

In flotation plants where the feed is irregular in tonnage and dilution,

[1] J. V. N. Dorr and L. D. Dougan, *Bull. Am. Inst. Min. Eng.*, **140**, 1235 (1918); *Trans.*, **60**, 78.
[2] *Eng. Min. Jour.*, **106**, 484 (1918).
[3] *Bull. Am. Inst. Min. Eng.*, **134**, 273 (1918).
[4] *Min. Sci. Press*, **117**, 339, 349 (1918).
[5] P. T. Bruhl, *Eng. Min. Jour.*, **106**, 54 (1918).
[6] *Jour. Chem. Met. Min. Soc. So. Afr.*, **19**, 77 (1918).

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the Dorr agitator has shown its ability to even up these irregularities in an efficient and economical manner.

Principles, Theory and General Ideas

Treatment of Middlings.—The problem of middlings, consisting of included grains, is fundamentally a problem of specific gravity. It is generally considered that two minerals must have a difference of at least 1.0 in specific gravity in order to be concentrated by gravity methods, but it is not generally appreciated that an included-grain middling particle must have a fairly high percentage of the heavy mineral constituent in order to obtain this difference of at least 1.0, and this is the fundamental reason why separation is difficult.[1]

Iron-ore Treatment.—The problem of the low-grade silicious red hematites of the Birmingham district of Alabama is very important from the viewpoint of the conservation of our natural resources. This problem has been investigated by J. T. Singewald, Jr.,[2] who made many tests by use of heavy solutions and obtained promising results. If a commercial heavy-solution process should later be worked out along either the line of the tin-bromide process or of the Chance or Conkling processes, it would be of great value on these ores.

Testing.—The conducting of ore tests for the design of flow-sheets of new mills has been discussed by A. Schwarz,[3] who advocates the employment of fairly large-scale machines for final testing.

The results of concentration tests usually involve the factors of extraction, grade of concentrates, and concentration ratio, and therefore may not be directly comparable. To obtain the real efficiency of concentration in each test for basis of comparison, R. T. Hancock[4] figures the ratio of the per cent. assay of the valuable mineral in the concentrates to the per cent. assay of the valuable mineral in the feed, also a similar ratio for waste in the concentrates and feed, subtracts the latter from the former and multiplies the result by the ratio of the weight of the concentrates to the weight of the feed.

The value of a microscope on fine material, not only in examining mill products, but also in getting a quick indication of results in testing, has been brought out by Clayton, Thomas and Apgar.[5] This is especially true for flotation tests where a magnification of 20 to 80 diameters enables the operator quickly to count the grains in any given field and thus to obtain a fairly close figure on percentage.

[1] *Eng. Min. Jour.*, **106**, 13 (1918).
[2] *U. S. Bur. Mines Bull.*, **110** (1917).
[3] *Eng. Min. Jour.*, **105**, 792 (1918).
[4] *Min. Mag.*, **19**, 144 (1918).
[5] *Met. Chem. Eng.*, **18**, 514; **19**, 61 (1918).

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Mill Operation.—In the design of the Elko Prince 50-ton gold mill,[1] the working floors are mainly at one level and the machines requiring close attention, such as the Diesel engine, the filter, etc., are grouped near the center where they can be easily observed by the operator. This arrangement enables one man to keep general watch over the whole milling operation. This economy of labor would, of course, not be practicable in a large mill.

To save calculation in dealing with pulps, a chart has been prepared by H. R. Robbins[2] which enables a mill operator to read directly the relations between density and dilution.

Morale of Men.—The efficiency of a mill is to a considerable extent dependent on the efficiency of the mill crew and to promote the latter, P. T. Bruhl[3] offers the suggestion that a manager should always encourage his men by fair wages, bonuses, steady employment and by the promotion of their health, welfare and safety. Apropos to the last item it seems that the Safety First movement is making headway in the mills. Two papers by D. K. Glover and J. S. McKaig at the meeting of the National Safety Council in September, 1918, were devoted to a consideration of accidents in mills, coal breakers and coal washers, their causes and remedies.[4]

Examples of Practice

The flow-sheet of the *Alaska-Juneau mill* as originally constructed was given in Mineral Industry, **25,** 823, but its operation was found to be faulty and extensive alterations have been made so that the revised flow-sheet on which they propose to operate is as follows:

The ore is delivered in 12-ton steel ore cars to (1).

(1) Two revolving tipples, each holding four cars. To (2).

(2) Coarse ore-bin holding 3000 tons. By four 60-in. apron feeders to (3).

(3) Two grizzlies with 12-in. spaces. Oversize to (4); undersize to (5).

(4) Two sorting platforms. Waste delivered into stone-boats on track leading to dump; residue to (5).

(5) Four 36- by 48-in. Buchanan jaw-breakers, crushing to 6 in. To (6).

(6) Four grizzlies with 6-in. spaces lying over four grizzlies with 2.5-in. spaces. Over 6 in. to (7); through 6 on 2.5 in. to (8); through 2.5 in. to (9).

(7) Four sorting belts. Waste by conveyor or stone-boats to dump; residue to (8).

(8) Four No. 6D Gates gyratory breakers. To (9).

(9) Four 30-in. belt-conveyors. To(10).

(10) Four 2.5-in. screens. Oversize by 36-in. conveyor to (11); undersize by similar conveyor to (19).

(11) One 2.5-in. screen. Oversize by conveyor to (12); undersize to (19).

[1] J. V. N. Dorr and L. D. Dougan, *Bull. Am. Inst. Min. Eng.*, **140,** 1235 (1918); *Trans.*, **60,** 78.
[2] *Min. Sci. Press*, **116,** 584 (1918).
[3] *Eng. Min. Jour.*, **106,** 658 (1918).
[4] *Eng. Min. Jour.*, **106,** 897 (1918). *Col. Guard.*, **116,** 1198 (1918). *Coal Age*, **14.** 901 (1918).

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(12) One grizzly with 4-in. spaces. Oversize to (13); undersize to (14).

(13) One picking-belt. Waste to dump; residue to (15).

(14) Conveyor. Some waste is picked off to dump. Residue to (15).

(15) Fifty stamps with 1-in. bar screens. To (16).

(16) One ⅜-in. screen. Oversize to waste dump; undersize to (17).

(17) Shovel-wheel dewaterers. Sands to (18); overflow to (23).

(18) One 6- by 12-ft. trunnion discharge tube mill. To (22).

(19) From (10) and (11). Mill ore-bin holding 8000 tons. By twenty-four 30-in. apron feeders to (20).

(20) Twelve 8- by 6-ft. ball mills with trunnion discharge. To (21).

(21) Twelve double trommels on the discharge trunnions of the ball mills, with coarse and 7-mesh screens. Over coarse screen is pebbles to bin for tube mill; through coarse screen on 7 mesh, by six 10- by 14-in. elevators to (20); under 7 mesh to (22).

(22) From (18) and (21). Twelve Deister classifiers with one spigot each. Spigot (+28 mesh) to (24); overflow to (23).

(23) Twenty-four settling tanks. Spigots to (25); overflow to waste.

(24) Twenty-four Deister tables. Lead concentrates to (27); iron concentrates to (30); middlings to (26); tailings to waste.

(25) Seventy-two Deister tables. Products like (24).

(26) Twenty-four Wilfley tables. Iron concentrates to (30); tailings to waste.

(27) Two amalgamating barrels followed by amalgam traps and plates. Amalgam to clean-up room; pulp by two Krogh centrifugal sand pumps to (28).

(28) Dewatering box. Spigot to (29); overflow to (37).

(29) Deister table. Gold to clean-up room; lead concentrates to market; iron tailings to (32).

(30) Two 10-in. elevators. To (31).

(31) Two shovel-wheel unwaterers. Sand to (32); water to sump.

(32) Two 5- by 5-ft. ball-peb mills. To sump and thence by two Krogh centrifugal sand pumps and distributor to (33).

(33) Two Deister classifiers with four spigots each. Spigots separately to (34); overflow to (37).

(34) Seven Deister tables. Lead concentrates to (27); middlings to (32); iron tailings by Krogh centrifugal sand pump to (35).

(35) Dewatering cone. Spigot to (36); overflow to waste.

(36) Amalgamating barrel, trap and plate, in series. Gold to clean-up room; pulp to waste.

(37) One 8-ft. Callow cone. Spigot to (38); overflow to waste.

(38) Amalgamated plate. Gold to clean-up room; pulp to (39).

(39) Deister double-deck slime table. Lead concentrates to market; iron concentrates to (30); tailings to waste.

A comparison of this flow-sheet with the original shows the following main points. (1) Sorting has been introduced all along the line even to the point of screening out the coarse hard barren waste from the discharges of the stamp and ball mills. (2) Stamps in the old experimental mill are used on ore too coarse for the ball mills, and thus help increase the crushing capacity. (3) The No. 9K Gates gyratory breakers have been changed to No. 6D and the grated ball mills have been changed to the open-discharge type. These two changes have been discussed already

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under "Crushing." (4) The concentration on tables in roughing and finishing stages has been discarded for a single step in tabling. (5) All concentrates are amalgamated with the result that, whereas both lead and iron concentrates were formerly intended to be smelted, now only a concentrate rich in lead is smelted, the iron concentrate being so reduced in value by amalgamation as to be a waste product. In addition to these major alterations a great many minor changes have been made in the way of feeders, launders, elevators, bins, grizzlies, conveyors, piping, etc., all for the purpose of increasing capacity and saving, and reducing costs. Altogether the cost of the changes will amount to over $500,000, but it is expected that they will result in a mill that will receive 16,000 tons per 24 hr. and will reject 8000 tons as waste and mill the remaining 8000 tons of ore and show a satisfactory profit.

This mill is an excellent example of the troubles that occur in the starting of a new mill, especially where the mill is a large one and where some novel features are being tried, and it therefore seems worth while to go into some details of the circumstances in this particular case.

The occurrence of the pay ore has a very important bearing on the milling. The gold is practically all free and always occurs in quartz and then closely associated with sulphides of lead, zinc, iron, copper, etc. The pay quartz occurs in stringers and veinlets scattered through a slate vein formation that is about 1000 ft. wide and more or less intruded with gabbro dikes.

In addition to the pay quartz there occurs some barren quartz outside the vein and also some non-mineralized quartz in certain low-grade sections of the vein, but this non-paying quartz is easily distinguished and eliminated from the pay quartz. Roughly 18 per cent. of the vein matter is pay quartz assaying $6.00 in free gold per ton, 12 per cent. is gabbro assaying $0.50 in free gold per ton; and 70 per cent. is slate assaying $0.10 free gold per ton. The sulphides are massive and very friable, while the quartz in which they occur is in turn much more friable than the enclosing tough slates and gabbros. It breaks free from the slate, but not so free from the dike rock. Nevertheless, the problem of recovering the gold is more one of abrasion and selective crushing than one of wholesale crushing of the entire mass.

The mill was originally planned to operate on the wholesale treatment basis without selection of ore. It was expected to treat 8000 tons in 24 hours at an operating milling cost of not over 18 cts. per ton, this being the cost of milling 1800 tons per day in the Treadwell 300-stamp mill on the opposite side of Gastineau Channel. The actual results obtained in the first six months of 1918 were 406,939 tons milled, or 2243 tons per day,

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at a cost of 59.6 cts. per ton. The best monthly average was 3832 tons per 24 hours in January. During this period the ore came to the mill largely unselected and was therefore low grade. But the main point was that the mill was handling less than half its estimated capacity at three times the estimated cost. It was during this period that the 50 stamps in the old experimental mill were incorporated in the flow-sheet to help out the crushing, as explained earlier in this article under "Ball Mills."

Aside from the crushing, however, it was finally realized that a mistake had been made in the mill process and that it was absolutely necessary to introduce sorting and selective crushing. Accordingly in the preceding revised flow sheet will be found provision for sorting at various stages. As the mixture of ore and waste from the mine is delivered to the mill, 90 per cent. of the material over 12-in. size is waste and much of this waste rock, up to the size of a ton or over in weight, is discarded off the coarse grizzly and platform (4). Similarly the oversize of the 6-in. grizzly is sorted on the belts (7), where the quartz constituting less than 5 per cent. of the whole is pushed off into the gyratory breakers and the remaining 95 per cent. goes to waste. Exactly the same procedure is practised on the belt (13) for material between 6 and 4 in., the quartz being pushed off into the stamp-mill bin and the residue going to waste. It is also possible to treat the 4- to 2½-in. material in the same way on the conveyor (14). The stamps crush selectively so that by installing the ⅜-in. screen (16) a hard barren oversize, 1 in. to ⅜, is made to go to waste. Finally the hard barren niggerheads coming out the ball-mill discharge are removed by the coarse inner screen of the trommel (21). These make excellent pebbles for grinding in the tube mill and are used in part for this purpose, but the excess goes to waste.

In this revised flow sheet for treating 16,000 tons of ore and waste in 24 hours it is estimated that the cost of discarding 8000 tons of waste will be 5 cts. per ton and that the 8000 tons of ore remaining will yield $1.80 gold per ton at a milling cost of 25 cts. per ton. This makes an average treatment cost of 15 cts. per ton for the 16,000 tons of ore and waste coming to the mill.

The present milling practice of the *Utah Copper Co.* shows a great change from the original mill and the description of the present methods by T. A. Rickard[1] is timely, especially as the original flow-sheets are given for comparison.

In the *Joplin district of Missouri* the milling practice has always been a subject of criticism by outsiders and this same view is shown by T. A.

[1] *Min Sci. Press*, 117, 713, 749 (1918)

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Rickard in his description of the mills of this section.[1] That there are losses in the jigging mills which can be saved is indicated by the Big Hurricane mill, described by T. Shiras,[2] which not only has found it economy to install a table plant, but has even added a second table plant after the first. In the most modern mill the practice is much improved, as illustrated in the mill of the Eagle-Picher Lead Co., described by H. W. Kitson,[3] which has an elaborate and up-to-date system involving jigs, tables and flotation.

The comprehensive investigation and report by the U. S. Bureau of Mines on milling in the Joplin district, summarized in MINERAL INDUSTRY, **25,** 825, has now been published in full detail.[4]

The work in flotation at *Broken Hill, Australia,* tends to overshadow the rest of the practice, but the gravity concentration of ore and tailings is likewise kept at a high standard, as will be found by a perusal of G. C. Klug's very comprehensive article on the Zinc Corporation plant.[5]

TREATMENT OF COAL

General.—If the same attention were given to the treatment of coal as to the treatment of ore, a remarkable improvement would result, but, as it is, although there are exceptions, coal washing is carried on in a rather non-progressive and inefficient manner. The reason appears to be that there is not the same incentive in coal washing as in ore dressing on account of two factors: (1) the low value of the product which makes losses of less consequence, and (2) the unfortunate marketing system whereby the total value of the output is based, in the majority of cases, more on the tonnage than on the quality of the product.

A scientific study of this subject has been made by T. J. Drakely,[6] including tests of products from various operating plants. It is not possible to summarize his work within the limits of this review and the reader is therefore referred to the original article, but some idea of its scope may be obtained from the list of subjects covered, which included: theory of coal separation; impurities in coal; effect of sizing, draining, and removal of dust; draining coal and handling slime; operation of jigs; breakage in handling; methods of testing and calculation of efficiency of operation; results of tests; conclusions and recommendations for improvement.

[1] *Min. Sci. Press,* **116,** 325 (1918).
[2] *Eng. Min. Jour.,* **105,** 313 (1918).
[3] *Eng. Min. Jour.,* **105,** 727 (1918).
[4] C. A. Wright, *U. S. Bur. Mines Bull.,* **154** (1918).
[5] *Min. Mag.,* **19,** 243, 298 (1918).
[6] *Inst. Min. Eng.,* **54,** 418; **55,** 158 (1918). *Coll. Guard.,* **115,** 125 (1918). *Manchester Geol. Soc.,* **35,** 244 (1918).

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Anthracite Practice.—In cleaning anthracite, one of the lines of development has been in the substitution of steel breakers for wood. Steel is stronger, longer lived, and more economical in the end. One of the newest steel breakers is that of the Franklin Colliery of the Lehigh Valley Co., which has been described by G. W. Harris.[1] This breaker prepares the coal by both the dry picking method and the wet jigging method, although there is a tendency to use the wet method as being cheaper. One interesting point in these modern breakers is that all breaker refuse slate is crushed to between ¼- and ½-in. size in a gyratory breaker followed by a pulverizer, and silted into the mine for filling.

Another breaker, the Mineral Spring, has been described by D. C. Ashmead.[2] This uses the wet method of treatment. The building is of steel covered with corrugated iron and heated by exhaust steam. The glass window area amounts to 75 per cent. of the total area of the sides of the structure.

The old Drifton breaker of the Lehigh Valley Co., which was the first steel breaker in the anthracite district, has been remodeled and practically rebuilt. After 25 years of service it was just about worn out, which indicates an annual depreciation of around 4 per cent. A full description of the new breaker has been given by E. B. Humphrey.[3]

The latest steel breaker is at the Locustdale washery, Germantown, Pa., which is to wash an old culm bank. This has been described by W. L. Cross.[4] In all these modern breakers the latest devices are used to prevent breakage of coal in handling.

Bituminous Practice.—In washing bituminous coal the advance has come in simplification of plants and in the installation of machines which are mechanically more perfect and more compact, and more efficiently operated. The war demand for coal led to a call for small washing installations, and typical compact little plants, using a jig with the necessary coal and slate elevators and settling tanks, have been described by G. H. Elmore.[5]

Apparatus.—For screening, coal practice generally has come to shaking screens in place of revolving screens. This is true not only in plants which use screens and picking tables, but also in plants which supplement the screening and picking by washing. A combined shaking screen and picking table is the well known Marcus screen. The Carnegie Coal Co. uses this apparatus at its bituminous coal plants in Pennsylvania and the installations have been described by R. G. Miller.[6]

[1] *Coal Age*, **13**, 660 (1918).
[2] *Coal Age*, **13**, 488 (1918). *Coll. Guard.*, **115**, 993 (1918).
[3] *Bull. Am. Inst. Min. Eng.*, **134**, 199 (1918). *Coal Age*, **13**, 580 (1918).
[4] *Coal Age*, **13**, 956 (1918).
[5] *Coal Age*, **14**, 122 (1918).
[6] *Coal Age*, **14**, 171 (1918).

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A new form of screen is on the plan of the horizontal bar screen or grizzly, but substitutes traveling steel cables for fixed bars. As the cables carry the coal forward the fines drop down between the cables, while the oversize is delivered at the end.[1]

On jigs the tendency to change from hand control to automatic delivery of slate is well marked. One form, described by Elmore, consists of a float resting on the layer of slate in the jig bed. As the slate bed rises the float rises and, through a system of levers, causes a pawl to drop and engage in a ratchet wheel operating the rotating slate-discharge roller. When sufficient slate has been drawn off to lower the float to its original position the pawl is lifted and discharge stops.

Another device, similar to the foregoing, has the float cause a clutch to engage, which starts the slate elevator and operates it until the slate bed drops to a level where the clutch becomes disengaged.[2]

The Baum apparatus has not found much application on this side of the water in the past, but in a recent installation by the Nova Scotia Steel and Coal Co. at Sydney the results show that slack coal running 1.8 to 2.75 per cent. sulphur and 12 to 15 per cent. ash can be washed down to 1 per cent. sulphur and 3 per cent. ash.[3] The special features of the Baum apparatus are the Baum jig, which uses compressed air to actuate the water and thus get quick pulsion and slow return, and the Baum draining conveyor, which in one operation compacts and filters the washed coal through the perforated conveyor buckets, and clarifies the water.

The Draper Washer,[4] used at the washery of the Glamorgan Coal Co., is a special form of hydraulic classifier which apparently works on the principle of hindered settling and has intermittent discharge of slate. Very good results are reported, which appear to be due in part to the fact that the coal feed is rather closely sized. No coal washer of this type can be expected to give good results on unsized coal. Incidentally, in describing this machine, the author goes into a complete description and discussion of various other washers that have been applied to coal.

The Rheolaveur, which is another form of classifier-washer used in Belgium on sized coal, has been improved by substituting a closed spigot and screw conveyor in place of the former open spigot which consumed too much water. This machine has been discussed by W. Galloway[5] with reference to its application in England. The special field of classifier washers appears to be on fine coal, because on coarse coal the water

[1] M. Raymond, *Coal Age*, **14**, 589 (1918).
[2] *Coal Age*, **13**, 682 (1918).
[3] W. H. Graham, *Can. Min. Inst.*, **21**, 231 (1918). *Min. Soc. Nova Scotia*, **20**, 10 (1918).
[4] G. Knox, *So. Wales Inst. Eng.*, **34**, 291 (1918). *Coll. Guard.*, **116**, 1186 (1918).
[5] *So. Wales Inst. Eng.*, **34**, 105 (1918).

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consumption is excessive. As compared to washing coal by sizing and classifying, tables appear to have the merit that they should do just as good work without requiring close sizing.

There is undoubtedly a greater field for jerking tables in coal washing than they occupy at present. The manufacturers do not appear to have studied and worked this field as they should. It is not enough to apply an ore-table directly to coal washing, but there is a special problem to be worked out to modify the table so as to apply it to the different conditions in the field of coal.

For recovering fine coal from sludge, the Dorr thickeners are finding a field in coal washing and are making substantial recoveries. In one case the undersize of $\frac{3}{64}$-in. anthracite screen was formerly a waste product and amounted to 5.6 per cent. by weight of the breaker output. Dorr thickeners recovered 55.35 per cent. of this total waste. The ash content of the total original undersize was 30.3 per cent. (dry basis); the ash in the recovered material was 22.6 per cent., which was reduced to 16 per cent. by tabling. The final table recovery represented 2.4 per cent. of the breaker output, or 43 per cent. of the previous loss.

In another case a bituminous washery having a capacity of 4000 tons of coal in 16 hr. has installed two 70-ft. thickeners, and plans to install two more, all for the purpose of recovering both the fine coal and the water overflowing the settling basin, which is used to collect the coal from the jigs. A 50-foot thickener clarifies the water overflowing from the refuse settling basin.

For draining washed bituminous coal the Cambria Steel Company has adopted concrete draining pits with filter bottom as being the most satisfactory. Such pits 16 to 24 ft. deep, receiving washed coal ranging from $\frac{1}{2}$ in. size to 0, will drain the coal in 24 hr. to 9 or 10 per cent. moisture or in 72 hr. to 8 per cent. moisture. During the filling period the average filtering capacity is 32 gal. of water per hour for each square foot of filtering surface. For full description of these tanks and calculations involved the reader is referred to the original article.[1]

Testing.—A very close approximation of the ash content of a product in a washing plant can be quickly obtained by finding its specific gravity. This saves much time over chemical analysis. A description of a modified specific-gravity flask for this purpose has been given by A. G. Blakeley.[2] For fine coal it has been found preferable to use kerosene instead of water.

Recovery of Pyrite.—In connection with the practice along this line discussed last year it is interesting to note that F. Arguillera[3] reports that such a recovery is made from the coal at the Mount Cenis mine.

[1] *Coal Age*, **14**, 1072 (1918).
[2] *Coal Age*, **14**, 1078 (1918).
[3] *Comptes rendus Soc. Ind. Min.* (1917), p. 46. From *Glückauf*, Jan. 1, 1916.

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AFRICA

The following tables give the mineral production of various countries in Africa. Provisional figures or estimates are given in full-faced type; other figures are official.

MINERAL PRODUCTION OF ALGERIA (*a*)
(In metric tons)

Year.	Antimony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1904...	160	1,804	350	38,420	468,737	511	.....	121	343,317	18,563	47,192
1905...	.....	1,784	.....	34,743	568,609	7,470	.....	270	334,784	26,986	67,922
1906...	50	2,786	.....	27,950	779,826	11,246	.....	216	333,531	22,615	74,351
1907...	799	16,259	.....	26,400	973,445	15,264	590	328	373,763	20,390	71,046
1908...	190	3,330	.....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,398
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910...	(*c*)4,475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	(*c*)7,428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	(*c*)2,165	316	.....	54,400	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(*c*)582	13,164	700	50,399	1,349,000	13,953	18	168	377,934	26,969	82,256
1914...	1,947	1,090	.....	.....	1,514,099	25,986	.....	...	485,552	.....	81,961
1915...	9,022	*Nil.*	.....	.....	818,705	15,046	*Nil.*	...	225,871	1,875	16,796
1916...	28,473	1,098	.....	.....	938,684	23,731	32	...	380,211	3,910	28,973

(*a*) From *Statistique de l'Industrie Minérale.*

MINERAL PRODUCTION OF EGYPT (*a*)
(In metric tons)

Year.	Gold, *Oz.*	Gold, Value.	Lead and Zinc Ores.	Manganese Iron Ore.	Nitrate Shale. (*b*)	Petroleum.	Phosphate Rock.	Talc.
1910.....	4,452	$92,023	.....	.....	.....	.....	2,397	.....
1911.....	5,068	104,756	.....	.....	.....	2,793	12,013	.....
1912.....	4,958	102,482	3,510	.....	4,939	27,962	70,918	.....
1913.....	4,602	95,123	7,156	.....	4,740	12,786	104,450	.....
1914.....	6,136	126,831	4,909	.....	3,370	99,680	71,945	.....
1915.....	7,096	146,674	2,988	.....	4,271	30,054	82,998	.....
1916.....	6,287	129,952	.....	.....	3,950	57,743	125,008	.....
1917.....	3,319	68,604	.....	.....	4,347	136,845	115,732	.....
1918.....	2,856	59,034	.....	27,498	5,039	281,885	31,147	137

(*a*) Statistics furnished by the Department of Mines, Egypt. (*b*) Estimated.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (*a*)
(In metric tons)

Year.	Antimony.	Asbestos.	Chrome Ore.	Coal.	Copper.	Diamonds, *Carats.*
1907.....	.....	.....	.....	104,395	.....	.....
1908.....	.....	.....	.....	148,885	.....	.....
1909.....	.....	.....	.....	155,035	.....	.....
1910.....	.....	.....	.....	163,357	.....	.....
1911.....	.....	.....	.....	192,806	.....	.....
1912.....	.....	*Nil.*	70,376	196,082	.....	587
1913.....	.....	295	64,405	220,747	.....	998
1914.....	.....	493	48,983	317,029	*Nil.*	1,005
1915.....	.....	2,042	61,556	371,737	1,028	.....
1916.....	39	6,256	90,302	445,918	3,578	1,021
1917.....	15	9,716	74,137	557,792	3,974	619
1918.....	15	8,712	31,789	499,177	3,306	450

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Year.	Gold, Oz.	Gold, Value.	Iron Ore.	Lead.	Tungsten Ore.	Silver, Oz.
1907	612,052	$10,589,385	.....	686	.....	147,324
1908	606,962	12,276,394	.....	913	.....	283,424
1909	623,388	12,985,430	.....	875	.....	262,133
1910	609,956	12,657,791	.....	679	.....	217,633
1911	628,521	12,991,500	.....	579	.....	187,641
1912	642,807	13,174,058	.....	533	.....	176,532
1913	689,954	14,261,343	.....	296	.....	142,390
1914	854,480	17,423,087	.....	152	1	150,793
1915	915,029	18,603,973	.....	25	4	186,233
1916	930,356	19,321,155	5,931	*Nil.*	3	200,676
1917	822,863	17,008,573	5,375	*Nil.*	11	211,939
1918	624,376	12,905,849	6,454	*Nil.*	37	175,722

(*a*) From Annual Report of the Rhodesia Chamber of Mines.

MINERAL PRODUCTION OF TUNIS (*a*)

(In metric tons)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1904....	18,846	16,800	455,197	27,200	1911...	63,700	36,100	1,592,000	(*c*)27,900
1905....	54,900	15,200	522,000	37,100	1912...	92,000	51,300	2,050,000	37,400
1906 ...	62,600	14,800	796,000	32,400	1913(*b*)	94,100	52,200	2,170,500	30,300
1907 ...	78,200	18,600	1,069,000	22,800	1914...	.....	.....	1,427,000	.....
1908....	149,600	37,500	1,300,500	26,500	.....	.....	.....	.....	.....
1909....	118,400	41,600	1,300,000	24,500	1917...	.....	41,400	1,000,009	15,000
1910....	199,700	(*c*)37,000	1,334,000	(*c*)32,500	1918...	.....	10,058	938,081	12,210

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) From *l'Echo des Mines.*

MINERAL AND METALLURGICAL PRODUCTION OF THE UNION OF SOUTH AFRICA (*d*)

Year.	Antimony.	Asbestos.	Coal.	Copper Matte. (*a*)	Corundum.	Diamonds. *Carats.*	Gold, *Oz.*	Gold, Value.	Graphite.	Gypsum.
1914.....	.....	1,209	8,614,417	29,797	12	2,801,016	8,396,068	$173,546,726	35	1,820
1915.....	90	2,172	8,414,653	29,436	69	103,385	9,096,410	188,022,795	42	2,884
1916.....	734	4,731	10,168,623	23,210	767	2,346,330	9,296,963	192,168,225	61	4,054
1917.....	.....	.....	10,549,783	20,499	.....	2,892,101	9,018,150	186,405,147	.....	.....

Year.	Iron Pyrite.	Lead.	Lime.	Magnesite.	Mica.	Salt. (*b*)	Silver, *Oz.*	Soda (crude).	Talc.	Tin. (*c*)
1914.....	.....	138	67,159	582	.....	40,939	890,781	2,635	.....	3,484
1915.....	554	183	70,100	637	2	45,830	966,176	6,404	45	3,496
1916.....	5,362	409	79,481	619	13	57,173	968,935	6,400	134	3,317
1917.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*a*) About 45 per cent. copper. (*b*) Including by-products. (*c*) Concentrates, 67.5 per cent. tin. (*d*) Official statistics of the Department of Mines and Industries. The figures correspond to sales or shipments in the year indicated, rather than mine output; the figures are in metric tons except where otherwise stated.

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AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian states and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the states are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES (*a*)
(In metric tons or dollars; £1 = $5) (*b*)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1904.....	376	111	41	404	6,116,126	173,742	6	2,470
1905.....	2,745	394	56	53	6,738,252	165,568	*Nil.*	487
1906.....	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(*g*)
1907.....	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(*g*)
1908.....	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(*g*)
1909.....	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(*g*)
1910.....	1,154	99	7	*Nil.*	8,304,693	286,854	10	(*g*)
1911.....	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(*g*)
1912.....	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(*g*)
1913.....	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(*g*)
1914.....	3,089	37	15	*Nil.*	10,557,911	309,677	*Nil.*	(*g*)
1915.....	1,443	646	18	*Nil.*	9,601,137	424,479	*Nil.*	(*g*)
1916.....	330	630	30	*Nil.*	1,145,308	444,632	*Nil.*	(*g*)
1917.....	.....	.....	.....	.....	8,431,081	436,180	.....	.....
1918.....	.....	.....	.....	.....	9,314,229	618,633	.....	.....

Year.	Copper Matte, Ingot, and Regulus.	Diamonds. *Carats.*	Gold. (*b*)	Lead, Argentiferous. (*f*)		Lead, Pig. (*f*)	Molybdenite.	Opal.
				Ore.	Metal. (*e*)			
1904....	6,654	14,296	$5,576,966	373,362	30,212	(*d*)5,977	26	$285,000
1905....	7,899	6,354	5,669,099	420,266	28,244	214	20	295,000
1906....	9,911	2,827	5,249,762	377,890	22,573	60	34	282,500
1907....	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395,000
1908....	9,215	2,205	4,646,451	364,488	(*h*)	15,174	9	209,000
1909....	7,078	5,474	4,231,211	273,628	(*h*)	15,724	29	309,000
1910....	13,096	3,606	4,011,055	322,780	(*h*)	21,534	50	331,000
1911....	12,295	5,771	3,743,672	343,902	(*h*)	17,552	21	286,500
1912....	11,211	2,239	3,416,560	350,850	(*h*)	17,528	57	170,349
1913....	9,619	5,573	3,093,331	397,783	(*h*)	23,947	80	143,513
1914....	6,713	1,580	2,573,496	342,411	(*h*)	26,405	62	132,670
1915....	7,085	839	2,738,677	287,329	(*h*)	30,793	33	32,015
1916....	6,270	1,901	2,235,357	253,872	(*h*)	25,876	55	106,365
1917....	6,685	.....	1,698,517	.....	.....	.....	.....	.....
1918....	6,619	.....	1,801,287	.....	.....	.....	.....	.....

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Year.	Platinum. *Kg.*	Oil Shale.	Silver. *Kg.*	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1904.....	16.6	38,477	34,880	586	1,084	106	58,523
1905.....	12.4	38,838	12,987	726	817	228	105,189
1906.....	6.4	32,965	8,865	(h)	1,698	245	105,325
1907.....	8.6	48,088	63,573	(h)	1,945	409	241,015
1908.....	4.2	47,044	77,490	(h)	1,822	247	281,147
1909.....	13.7	49,500	53,430	(h)	1,974	129	379,907
1910.....	10.3	69,385	55,176	(h)	1,898	168	476,125
1911.....	14.6	76,306	54,975	(h)	1,960	288	524,666
1912.....	19.0	87,399	74,314	(h)	2,107	231	528,872
1913.....	13.7	17,268	68,267	(h)	3,071	172	515,105
1914.....	7.6	50,880	89,318	(h)	2,355	200	365,059
1915.....	1.7	15,723	100,698	(h)	2,223	84	193,988
1916.....	2.6	17,706	87,139	(h)	2,163	268	213,118
1917.....	.....	32,189	.....	.....	.....	.....	273,020
1918.....	.....	32,935	.....	.....	.....	.....	353,403

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported, £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. In the case of lead, 101,811 long tons was produced in 1912 from N. S. Wales in Australia; see article on lead. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND (a)

(In metric tons or dollars; £1 = $5)

Year.	Bismuth Ore.	Coal.	Copper.	Gold. (b)	Lead.	Manganese Ore.
1904.....	20	520,232	4,440	$13,210,869	2,079	843
1905.....	15	537,795	7,337	12,249,157	2,464	1,541
1906.....	7	610,480	10,238	11,257,316	2,854	1,131
1907.....	6	694,204	12,959	9,641,789	5,240	1,134
1908.....	22	707,473	14,932	9,613,051	7,207	1,403
1909.....	11	768,720	14,727	9,416,576	5,323	613
1910.....	22	885,108	16,649	9,123,531	2,435	805
1911.....	10	905,568	20,709	7,981,791	1,799	1,167
1912.....	(c) 201	917,202	23,505	7,191,846	3,179	313
1913.....	(c) 185	1,045,243	24,050	5,492,585	3,663	27
1914.....	(c) 197	1,071,237	18,738	5,156,919	736	6
1915.....	(c) 253	1,041,003	89,318	5,303,515	494	203
1916.....	(c) 139	922,341	19,833	4,569,755	625	653
1917.....	(c) 137	1,065,353	19,370	3,706,135	489	21
1918.....	(c) 137	999,022	19,285	2,760,827	225	1,320

Year.	Molybdenite.	Opal.	Silver. *Kg.*	Tin Ore.	Tungsten Ore.
1904.....	(c) 22	$17,750	20,370	3,986	1,564
1905.....	64	15,000	18,716	4,008	1,434
1906.....	108	15,000	24,357	4,900	785
1907.....	68	15,000	28,662	5,222	627
1908.....	89	12,500	36,200	4,903	426
1909.....	94	10,000	31,140	3,379	617
1910.....	108	15,000	26,787	3,000	869
1911.....	(c)232	15,000	17,076	3,140	548
1912.....	104	14,600	17,712	3,284	636
1913.....	68	14,600	18,817	4,251	364
1914.....	79	9,700	7,899	2,119	245
1915.....	99	2,500	7,457	2,160	425
1916.....	83	2,500	7,561	1,734	376
1917.....	113	500	7,516	1,196	358
1918.....	112	1,500	4,743	1,333	253

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported, £1 = $4.866. (c) Includes bismuth and some tungsten.

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MINERAL PRODUCTION OF SOUTH AUSTRALIA
(In metric tons or dollars) (a)

Year.	Copper.		Gold. (b)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1906.....	535	8,339	$131,382	76,430	51	32,451	5,944	55,880	$11,045
1907.....	.....	8,058	99,948	85,954	.....	31,598	8,128	76,200	12,500
1908.....	.....	5,718	59,852	89,412	.....	29,973	11,177	76,204	22,500
1909.....	1,250	5,788	146,932	16,379	142	13,986	3,833	52,232	19,365
1910.....	.....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911.....	.....	6,017	72,990	42,976	.....	29,159	5,893	66,040	56,600
1912.....	.....	6,395	136,248	42,877	.....	51,412	6,198	65,338	51,044
1913.....	.....	7,174	134,275	61,669	.....	45,038	6,049	66,083	104,906
1914.....	.....	6,996	129,343	43,324	.....	54,955	6,184	66,083	179,425
1915.....	.....	7,851	125,689	241,252	.....	72,895	4,689	65,066	207,140
1916.....	.....	7,396	160,578	191,361	.....	75,843	5,094	67,469	142,331
1917.....	.....	7,329	147,605	333,673	.....	69,566	5,183	47,612	125,426
1918.....	.....	7,284	127,742	261,167	.....	73,372	8,204	89,944	96,787

(a) From *Mining Review*, Department of Mines, Adelaide, South Australia. (b) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA (a)
(In metric tons or dollars) (b)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (b)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1905.....	52,825	(d)	9,919	$1,520,101	6,401	76,424	3,953
1906.....	53,742	2,270	8,847	1,240,650	2,642	88,513	4,545
1907.....	59,833	1,261	8,378	1,350,836	3,048	91,216	4,412
1908.....	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909.....	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.....	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.....	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.....	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.....	55,960	2,000	4,645	690,369	*Nil.*	84,677	4,077
1914.....	61,807	3,343	7,634	542,437	*Nil.*	11,758	2,616
1915.....	65,612	67	8,031	383,450	(c)13,049	10,556	2,642
1916.....	56,470	98	6,406	326,372	(c)14,230	11,410	2,901
1917.....	61,433	784	5,922	299,634	(c) 7,809	9,730	2,680
1918.....	61,132	451	5,648	217,627	(c) 5,188	7,358	2,292

(a) From *Statistics of the Colony of Tasmania*. (b) Where value of gold is reported, £1 = $4.866 (c) Included with lead-silver ore. (d) Not reported. (e) Iron pyrite.

MINERAL PRODUCTION OF NEW ZEALAND (a) (b)
(In metric tons or dollars) (c)

Year.	Anti-mony.	Chrome Ore.	Coal.	Coke.	Copper Ore.	Gold. (c)	Kauri-gum.	Manga-nese Ore.	Silver. Kg.
1904...	.....	.....	1,562,520	.....	.....	$9,671,180	9,203	196	34,042.3
1905...	.....	.....	1,611,207	15	4	10,189,093	10,883	55	36,695.0
1906...	.....	.....	1,757,284	5	.....	11,050,219	9,300	16	43,251.5
1907...	100	.....	1,860,397	15	57	9,865,766	8,847	5	48,603.5
1908...	5	.....	1,890,844	2	13	9,755,303	5,618	*Nil.*	53,834.8
1909...	2	*Nil.*	1,941,923	23	5	9,765,575	8,382	6	56,410.0
1910...	*Nil.*	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8
1911...	20	*Nil.*	2,099,234	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2
1912...	.....	.....	2,177,615	4	*Nil.*	6,427,422	7,908	.....	24,237.8
1913...	.....	.....	1,919,472	28	.....	7,101,822	8,926	.....	30,344.6
1914...	*Nil.*	*Nil.*	2,313,519	17	3	4,356,856	8,581	*Nil.*	18,636.4
1915...	*Nil.*	*Nil.*	2,244,183	24	*Nil.*	8,245,695	4,650	*Nil.*	29,782.4
1916...	*Nil.*	*Nil.*	2,293,475	34	*Nil.*	5,835,366	5,536	*Nil.*	24,479.7

(a) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (b) The exports are stated to be identical with the production, with the exception of coal (c) Where gold is reported, £1 = $4.866.

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MINERAL PRODUCTION OF VICTORIA (a)
(In metric tons or dollars)

Year.	Antimony Ore	Coal.	Lignite.	Gold. (c)	Building Stone, etc. (b)	Tin Ore.
1903.....	5	65,230	5,752	$15,860,815	$213,245	34
1904.....	20	123,695	Nil.	15,824,952	1,496,110	72
1905.....	25	157,648	Nil.	15,443,438	1,560,090	126
1906.....	208	163,201	Nil.	15,962,804	1,705,420	108
1907.....	4,575	140,802	Nil.	14,377,166	2,023,130	105
1908.....	3,740	115,283	Nil.	13,867,312	2,138,070	80
1909.....	1,779	130,230	Nil.	13,522,400	2,226,220	90
1910.....	1,283	374,775	660	11,789,077	2,542,815	42
1911.....	1,116	664,326	6,232	11,789,077	2,820,800	33
1912.....	2,470	598,599	4,076	9,924,032	3,385,070	48
1913.....	6,253	603,811	3,034	9,189,593	3,261,815	58
1914.....	7,730	627,828	2,760	8,540,978	3,485,880	54
1915.....	11,113	588,104	2,864	6,794,771	3,361,662	96
1916.....	12,581	423,900	2,962	5,304,884	.....	124
1917.....	2,613	473,726	39,774	3,172,595	653,533	141

(a) From Annual Reports of the Secretary for Mines of the Colony. (b) Includes bricks, tiles, pottery and salt. (c) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF WESTERN AUSTRALIA (a)
(In metric tons or dollars)

Year	Tungsten Ore.	Coal.	Copper Ore.	Copper and Matte.	Gold. (b)	Iron Ore.	Lead Ore. (g)	Silver. Kg.	Tin Ore.
1907.....	.....	144,651	19,282	1,628	$35,087,500	1,112	(d) 214	5,887	(e) 1,529
1908.....	.....	178,061	8,427	486	34,061,426	Nil.	(d) 526	5,240	(e) 1,118
1909.....	1	217,741	7,071	846	32,973,349	Nil.	(d) 214	5,500	(e) 703
1910.....	2	266,361	6,410	1,301	30,397,162	10	252	5,478	509
1911.....	10	253,900	9,974	832	28,331,272	Nil.	1,575	5,215	502
1912.....	Nil.	299,815	9,689	28	26,511,841	Nil.	1,898	5,144	666
1913.....	(g)1	319,048	(g)4,411	(g)83	27,160,557	Nil.	(d)3,222	5,848	(h)496
1914.....	(g)0.5	324,530	(g)3,978	(g)186	25,484,960	Nil.	(d)3,642	6,005	(gh)368
1915.....	(g)0.3	291,281	(g)749	(g)961	25,012,349	Nil.	(d)2,929	6,909	(gh)436
1916.....	(g)1	306,381	(g)660	(g)464	21,938,516	Nil.	(d)435	5,381	(gh)470
1917.....	Nil.	331,807	(g)982	(g)544	20,055,935	Nil.	(d)22	6,907	(gh)390

(a) From the *Report of the Department of Mines of Western Australia.* (b) £1 = $4.866 (d) Silver-lead and lead ore. (e) Includes ingots. (f) Total in previous years. (g) Exports. (h) Ore and ingot.

MINERAL IMPORTS OF AUSTRALIA (a)
(In metric tons, cwt. of 112 lb., or dollars; £1 = $5) (b)

Year.	Cement. Cwt.	Coal.	Coke.	Copper Ore. Cwt.	Gold. (b)				
					Ore.	Bullion.	Specie.	Foil. (c)	Total Value.
1908	915,033	14,833	10,368	3,959	$42,855	$4,625,498	$70,197	.....	$4,738,550
1909	848,337	16,144	44,668	4,533	35,687	4,865,436	56,280	.....	4,957,403
1910	1,612,004	314,393	17,161	23,027	35,712	4,653,044	126,556	.....	4,815,312
1911	1,670,117	10,498	22,608	10,201	62,951	7,707,919	124,248	.....	7,895,118
1912	2,603,792	16,152	15,839	18,449	93,885	5,478,177	1,190,890	.....	6,762,952
1913	2,511,828	4,928	27,304	25,085	118,263	5,699,945	910,064	.....	6,728,272
1914(e)	1,040,494	14,085	10,887	11,736	71,311	2,670,213	973,200	.....	3,714,724
1915(f)	1,407,099	13,580	15,852	14,037	112,035	2,105,421	16,773	.....	2,234,229
1916(f)	1,516,858	6,186	1,734	16,257	162,529	2,648,749	32,179	.....	2,843,457
1917(f)	150,025	56,081	312	28,974	168,558	962,279	(c)	.....	1,130,837
1918(f)	11,017	32,888	Nil.	9,448	(g)	(g)	(g)	.....	(g)

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Year.	Graphite.	Iron and Steel.			Lead Mfrs. *Cwt.*	Petroleum Products.		
		Bars, Rods Girders, Sheets, etc. *Cwt.*	Galvanized Plates and Sheets. *Cwt.*	Pig and Scrap. *Cwt.*		Kerosene. *Gal.*	Benzine, Gasoline, etc. *Gal.*	Paraffin.
1908...	$18,525	2,376,017	(d)1,253,624	820,834	2,703	17,154,940	782,859	1,560
1909...	44,925	2,559,798	(d)1,658,291	1,178,219	19,338	19,924,622	884,703	2,772
1910...	49,755	3,663,386	(d)2,131,911	1,073,933	9,111	19,660,890	1,339,381	3,963
1911...	38,910	4,215,986	(d)2,177,981	1,574,439	2 120	19,378,540	1,772,840	3,321
1912...	43,145	4,933,414	(d)2,416,367	1,719,585	955	24,292,539	12,294,617	2,832
1913...	48,925	5,070,590	(d)2,196,865	1,535,030	2,075	19,288,122	9,812,771	2,803
1914 (*e*)	26,595	2,377,790	(d)1,265,429	833,008	7,676	12,231,752	8,853,386	1,815
1915 (*f*)	41,795	3,236,889	1,676,033	1,352,011	2,650	20,444,196	12,446,797	2,790
1916 (*f*)	61,135	3,219,064	1,238,623	631,133	1,208	24,857,800	16,722,829	4,547
1917 (*f*)	44,246	2,020,416	452,590	376,515	426	22,626,762	20,412,125	2,463
1918 (*f*)	30,340	557,189	259,717	48,311	374	14,060,462	17,088,779	3,370

Year.	Potassium Nitrate. *Cwt.*	Quick-silver.	Salt. *Cwt.*	Silver. (*b*)			Sulphur. *Cwt.*	Zinc, Bar and Sheet. *Cwt.*
				Ore. *Cwt.*	Bullion. *Kg.*	Specie.		
1908.....	6,036	56.4	390,535	.....	189.8	$1,019,738	420,098	£27,449
1909.....	6,894	58.4	273,442	1,972	622.2	157,352	405,396	58,451
1910.....	7,016	57.6	444,081	14,609	1,411.7	1,615,775	357,332	70,339
1911.....	10,257	42.4	753,849	1,734	1,115.8	1,648,430	386,764	86,362
1912.....	10,127	52.8	468,507	3,836	1,580.3	1,350,870	465,643	61,736
1913.....	10,552	46.0	533,055	10,396	1,180.4	861,500	603,865	41,650
1914(*e*)...	6,349	20.9	139,024	.....	622.5	546,481	246,586	21,147
1915(*f*)...	7,500	24.0	372,160	319	586.1	2,062,386	421,497	29,193
1916(*f*)...	7,522	34.0	270,475	.....	174.2	1,068,988	825,648	12,303
1917(*f*)...	3,421	15.5	78,578	.....	143.0	218,814	991,780	3,743
1918(*f*)...	5,926	32.3	56,785	.....	15,558	251,728	792,904	4,775

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1 = $4.866. (*c*) Included with bullion. (*d*) Includes ungalvanised corrugated. (*e*) First six months. (*f*) Fiscal year ending June 30th. (*g*) Data withheld.

MINERAL EXPORTS OF AUSTRALIA (*a*)

(In metric tons, cwt. of 112 lb., or dollars; £1 = $5)

Year.	Alunite. *Cwt.*	Anti-mony Ore. *Cwt.*	Bis-muth Ore. *Cwt.*	Cement. *Cwt.*	Chrome Ore. *Cwt.*	Coal.	Coke.	Co-balt Ore. *Cwt.*	Copper.	
									Ore.(*f*) *Cwt.*	Ingot and Matte. (*Cwt.*)
1908...	21,640	23,931	1,396	49,116	22,300	2,601,962	28,068	.....	103,694	765,298
1909...	73,795	14,976	1,763	23,585	.....	1,608,173	24,798	280	162,904	676,664
1910...	23,290	12,796	1,456	34,259	.....	1,730,473	10,457	186	260,597	765,176
1911...	20,274	17,985	2,307	45,247	.....	1,714,959	8,543	.....	264,688	806,005
1912...	68,500	30,894	610	27,724	453	2,186,946	9,852	.....	259,690	876,773
1913...	44,700	51,007	588	18,221	.....	2,132,201	8,163	.....	177,757	846,411
1914(*g*)	24,200	30,661	151	23,813	.....	1,182,548	2,636	.....	62,658	392,005
1915(*h*)	52,400	50,316	1,295	24,591	.....	1,394,151	14,563	.....	142,363	669,189
1916(*h*)	12,800	74,631	2,602	27,345	.....	944,931	25,658	.....	89,382	737,841
1917(*h*)	6,500	51,995	1,883	15,406	.....	656,981	35,286	.....	602	721,785
1918(*h*)	.....	10,601	1,864	21,384	.....	362,466	37,901	.....	.....	541,416

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Year.	Gold. (b)				Iron and Steel Bars, Rods, Girders, Sheet, etc. *Cwt.*	Lead.		
	Ore.	Bullion. (c)	Specie.	Total Value.		Pig. *Cwt.*	Contained in Matte. *Cwt.*	Manufactures. *Cwt.*
1908....	$20,539	$18,924,716	$50,794,544	$69,739,799	170,636	1,483,415	648,784	20,161
1909....	270,131	17,265,872	26,028,555	43,564,558	158,468	808,297	573,072	14,067
1910....	429,288	12,070,522	16,598,747	23,098,557	154,846	1,326,702	473,556	13,350
1911....	327,107	10,456,322	47,831,267	58,614,696	116,893	1,358,308	397,342	14,610
1912....	340,474	9,135,487	50,801,322	60,277,283	138,061	1,438,681	502,264	17,916
1913....	371,257	6,695,757	10,184,007	17,251,021	184,433	1,529,075	524,513	14,989
1914 (g).	45,825	2,119,722	4,882,690	7,048,235	71,337	676,457	376,587	10,239
1915 (h).	255,883	3,325,439	9,447,081	13,028,403	179,122	1,427,455	737,416	14,190
1916 (h).	125,144	5,053,472	46,308,413	51,487,029	221,548	1,636,974	821,160	10,868
1917 (h).	4,705	1,735,288	54,768,149	56,503,437	269,013	2,372,935	548,880	14,895
1918 (h).	(k)	(k)	(k)	(k)	80,307	1,904,856	311,659	23,366

Year.	Molybdenum Ore. *Cwt.*	Salt. *Cwt.*	Shale, Oil.	Silver.		Tin.		Zinc, Bar and Sheets. *Cwt.*
				Ore. (d) *Cwt.*	Bullion. (e) *Kg.*	Ore. *Cwt.*	Block. *Cwt.*	
1908.....	2,116	240,348	19,173	1,137,746	326,249	49,409	121,979	307
1909.....	1,055	230,486	3,983	(f) 1,914,479	210,570	(f)57,902	111,262	167
1910.....	1,972	184,892	9,307	(f) 2,520,652	233,494	(f)48,209	87,529	1,807
1911.....	1,876	63,607	6,344	(f) 3,226,043	218,387	(f)55,721	82,935	1,050
1912.....	2,873	123,779	290	(f) 2,395,267	238,947	(f)64,704	77,501	15,971
1913.....	2,684	134,863	449	(f) 3,377,901	252,219	(f)89,384	68,392	12,236
1914 (g)..	2,009	47,560	283	(f) 1,701,932	126,139	(f)42,616	27,624	.....
1915 (h)..	2,080	111,001	457	(f) 553,173	213,102	(f)42,845	29,891	54,099
1916 (h)..	2,569	312,525	20	(f) 195,565	205,019	(f)48,111	68,690	46,132
1917 (h)..	3,525	244,377	19	61,713	174,524	39,931	61,085	43,325
1918 (h)..	3,341	316,234	.....	.....	162,168	3,806	73,199	15,363

(a) From Trade and Customs Returns, Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported, £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates. (g) First six months. (h) Fiscal year ending June 30th. (i) Silver-Lead Bullion. (k) Data withheld.

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AUSTRIA-HUNGARY

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina. Exports and imports are reported jointly.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA (a)
(In metric tons)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphalt and Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1900.....	620	3,004	201	153	924	4.0	10,992,515	21,539,917
1901.....	442	2,551	126	114	561	16.0	11,738,840	22,473,510
1902.....	62	2,866	18	24	927	8.0	11,045,039	22,139,683
1903.....	*Nil*	2,978	41	14	1,298	9.7	11,498,111	22,157,521
1904.....	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905.....	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906.....	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
1907.....	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
1908.....	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926
1909.....	*Nil*	*Nil*	450	*Nil*	2,975	*Nil*	13,713,043	26,043,716
1910.....	*Nil*	*Nil*	225	*Nil*	1,066	*Nil*	13,773,985	25,132,855
1911.....	*Nil*	*Nil*	270	.....	1,740	.....	14,379,817	25,265,334
1912.....	.....	.....	4,520	13	4,234	.....	15,797,890	26,283,690
1913.....	.....	.....	1,270	.....	3,026	.....	16,459,889	27,378,332

Year.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast.
1900.....	5,825	881	234	474	227	$47,183	33,663	1,894,458	1,000,207
1901.....	7,406	776	256	472	143	31,234	29,992	1,963,246	1,030,260
1902.....	8,455	914	248	271	74	4,652	29,527	1,744,498	991,827
1903.....	8,188	961	310	298	2,148	5,316	29,590	1,715,984	970,832
1904.....	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905.....	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906.....	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907.....	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
1908.....	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897
1909.....	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
1910.....	8,005	1,468	715	30	31,744	118,895	33,131	2,627,513	1,504,786
1911.....	10,974	1,760	767	*Nil*	29,647	134,840	41,599	2,765,815	1,596,148
1912.....	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
1913.....	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864

Year.	Lead.			Manganese Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1900.....	14,314	10,650	1,288	8,804	2,828	347,213	94,727	510	330,277
1901.....	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
1902.....	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
1903.....	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904.....	22,514	12,645	783	10,189	1,829	823,943	88,279	536	369,877
1905.....	23,339	12,968	865	13,788	798	794,391	86,856	520	343,375
1906.....	19,683	14,846	1,059	13,402	943	737,194	91,494	526	376,212
1907.....	22,792	13,598	863	16,756	1,091	1,725,808	89,370	527	395,053
1908.....	21,513	12,669	1,010	16,656	475	1,718,030	90,145	572	388,133
1909.....	20,550	12,941	840	18,045	620	2,086,342	92,337	585	359,801
1910.....	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
1911.....	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
1912.....	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
1913.....	25,751	22,312	305	16,540	2,999	1,081,090	130,608	820	337,563

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Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. Kg.			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1900.	21,641	39,572	7,067	862	51	40	50	52.0	11.3	38,243	6,742
1901.	21,363	40,205	7,073	4,911	42	49	45	48.0	13.0	36,072	7,558
1902.	22,288	39,544	8,781	3,721	47	50	45	46.0	10.0	31,927	8,309
1903.	21,958	39,812	9,105	4,475	57	34	49	45.0	5.8	29,544	8,949
1904.	21,948	39,032	8,742	6,288	77	38	52	17.0	11.4	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	59	16.0	13.9	29,983	9,326
1906.	21,944	38,940	745	15,125	55	42	56	16.0	10.3	32,037	10,804
1907.	22,636	38,742	*Nil*	24,099	53	47	44	11.0	11.2	31,970	11,208
1908.	22,241	39,867	*Nil*	17,429	68	39	37	9.0	8.4	31,266	12,770
1909.	21,102	39,002	*Nil*	12,725	36	52	39	18.0	10.2	33,955	11,688
1910.	23,629	49,692	.....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	.....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,355	.....	13,996	606	13	66	11.0	5.4	34,675	17,298
1913.	19,937	54,434	.....	10,561	939	11	52	11.2	4.5	34,225	19,508

(*a*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY (*a*)

(In metric tons or dollars; 1 crown = $0.203)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (*d*)	Lignite. (*d*)	Coke.	Briquets.
1901...	(*b*) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902...	(*b*) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903...	(*b*) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(*c*)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	.....	.....	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	.....	.....	3,245	1,302,103	7,734,166	186,048	108,873
1911...	2,616	892	3,861	.....	.....	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	.....	.....	3,692	1,302,405	8,287,871	149,913	118,505
1913...	11,017	1,048	3,025	45,860	(*f*)25	3,148	1,319,918	8,954,133	160,073	117,186
1914...	.....	.....	.....	.....	.....	.....	909,882	.....	128,118	112,040

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese. Ore.
				Ore. (*d*)	Pig.	Cast.	Ore.	Pig.		
1901...	162	805	$2,189,692	1,557,300	430,686	20,640	(*b*) 10	2,029	238	4,591
1902...	89	909	2,260,135	1,562,238	416,835	18,569	(*b*) 20	2,244	219	7,237
1903...	45	982	2,243,521	1,439,132	396,674	18,875	(*d*)3,698	2,057	257	5,311
1904...	63	1,277	2,437,988	1,524,036	370,297	17,203	(*d*)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(*e*)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(*e*)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	477	13,833
1913...	405	627	1,945,958	2,059,076	608,966	13,986	488	1,137	412	19,006
1914...	358	....	.....	1,722,340	494,441	.....	.....	1,368	.....	11,413

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Year.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. Kg.	Salt.	Silver. Kg.	Sulphur.	Sulphuric Acid.	Zinc. Ore.(b)	Zinc. Spelter.
1902...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	.....
1903...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	.....
1905...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	.....
1906...	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
1907...	259	2,404	99,503	40,400	(c)	12,695	(c)	1,232	(c)	(c)
1908...	294	2,427	95,824	78,000	(c)	12,612	144	1,444	135	(c)
1909..	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	.....
1910..	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	.....
1911...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	.....
1912...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	778	.....
1913...	57	2,105	106,629	88,800	256,448	8,696	42	555	407	.....
1914...	.....	.....	102,370	.....	.....	.....	.....	.....	.....	.....

(a) From the *Annuaire Statistique Hongrois*. (b) Includes only that part of the crude output that was not smelted into a refined product. (c) Not reported. (d) Total production. (e) Exported. (f) Kilograms.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA (a)

(In metric tons)

Year.	Chrome Ore.	Copper. Ore.	Copper. Metal.	Iron. Ore.	Iron. Pig.	Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
1902...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(b)
1906...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907...	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148
1908 (c)	315	(b)	*Nil.*	150,075	48,900	630,500	6,000	(b)	*Nil.*	22,100
1909 (c)	310	(b)	*Nil.*	145,200	48,850	675,400	5,000	(b)	*Nil.*	22,500
1910...	320	(b)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
1911...	250	(b)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
1912...	200	.....	*Nil.*	150,420	53,270	852,920	4,650	6,216	*Nil.*	23,124
1913...	305	.....	.....	220,131	53,587	841,140	4,700	7,701	.....	24,176
1914...	211	.....	.....	178,830	44,078	806,831	4,120	4,459	.....	25,730

(a) From *Oestr. Zeit. f. B.-u. H.* (b) Not reported. (c) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY (a)

(In metric tons or dollars; 5 Crowns = $1)

Year.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony. Ore.	Antimony. Regulus. Kg.	Arsenic. (b)	Asbestos. Crude. (c)	Asbestos. Manufactures.
1900.....	430	154	1,435	46	23,000	320	1,085	1,238
1901.....	413	153	1,882	27	1,500	351	1,678	1,032
1902.....	537	151	2,161	40	18,200	351	2,038	798
1903.....	508	150	2,670	42	87,200	371	3,395	1,221
1904.....	602	231	2,346	64	21,000	384	2,517	1,240
1905.....	774	477	2,775	42	24,700	342	5,962	208
1906(f)..	513	216	2,840	79	38,900	83	7,025	111
1907.....	545	255	3,200	231	89,900	325	5,729	180
1908.....	567	323	2,606	304	128,200	349	9,484	139
1909.....	359	418	1,831	95	80,100	370	12,003	200
1910.....	589	303	1,474	96	121,800	416	11,602	250
1911.....	375	516	1,317	98	124,600	377	16,071	276
1912.....	253	1,224	1,396	91	49,000	24	24,615	338
1913.....	454	589	1,334	.....	.....	47	17,575	248

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Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude, and Boric Acid.	Refined.			
1900.....	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901.....	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902.....	5,732	1,273	6,266	2,163	174	18,658	2,596	2,668
1903.....	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904.....	8,211	1,064	6,233	2,752	142	20,259	3,407	1,209
1905.....	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906(f).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.....	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.....	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.....	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.....	15,897	1,101	21,486	5,284	166	81,251	1,885	1,271
1911.....	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.....	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.....	24,794	1,011	23,350	5,652	356	61,261	3,097	2,845

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate.
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1900.....	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901.....	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902.....	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903.....	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904.....	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,508
1905.....	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906 (f)...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907.....	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908.....	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909.....	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910.....	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911.....	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912.....	24,628	11,848,535	34,871	(h)915,547	765	45,460	850	16,131
1913.....	22,467	13,689,149	33,097	933,669	150	36,451	572	6,937

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (d)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1900.....	343	342	5,649	$1,111,831	$7,230,251	302	1,348	15,462	577
1901.....	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902.....	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903.....	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904.....	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905.....	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(f)..	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,961	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	708	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1,053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	5,855,085	3,626,938	1,499	8,696	24,659	975

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Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1900.....	233,156	95,530	$4,533,599	10,313	501	7,916	141	354	106
1901.....	218,476	90,287	4,443,670	10,902	1,270	10,722	189	433	135
1902.....	197,525	43,314	4,304,818	11,584	1,879	8,706	149	428	221
1903.....	217,979	47,354	4,508,224	11,025	1,355	9,190	141	423	173
1904.....	182,515	35,091	4,976,342	9,402	1,436	7,917	146	372	138
1905.....	228,149	49,383	5,722,976	33,256	247	7,282	101	349	88
1906(*f*).....	232,558	57,341	6,153,698	5,085	189	11,732	82	310	75
1907.....	390,322	151,848	(*g*)29,520	29,268	204	12,547	98	381	126
1908.....	423,940	224,740	(*g*)45,235	88,396	559	17,116	161	616	201
1909.....	374,088	147,459	(*g*)48,344	34,025	7,560	20,697	230	599	57
1910.....	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911.....	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912.....	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913.....	942,312	188,324	.....	.....	8,055	12,455	402	367	113

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke.
1900.....	2,100	7,016	1,672	4,958	258	406	36	2,664
1901.....	2,529	6,367	1,595	5,109	277	788	22	2,896
1902.....	2,621	15,595	1,410	4,831	265	225	90	3,234
1903.....	3,118	38,529	1,395	4,733	268	385	7	3,097
1904.....	2,997	35,357	1,282	5,563	402	656	24	2,676
1905.....	3,495	30,483	1,467	6,018	632	391	14	2,432
1906(*f*)...	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907.....	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908.....	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909.....	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910.....	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911.....	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912.....	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913.....	7,799	67,278	2,066	6,984	1,895	.....	39	4,264

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1900.....	20,813	22,963	5,080	204	1,029	3,633	11	60,317
1901.....	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902.....	24,830	15,864	4,238	225	485	3,377	11	60,235
1903.....	19,710	19,382	2,598	237	197	3,727	9	73,835
1904.....	20,110	22,715	1,470	193	222	3,557	3	65,397
1905.....	18,974	24,961	888	222	154	3,864	5	86,338
1906(*f*).....	13,522	9,693	403	178	602	3,729	(*e*) 5	87,973
1907.....	18,345	11,441	524	219	174	4,807	(*e*)38	130,270
1908.....	3,118	9,705	358	234	324	5,009	(*e*)98	130,793
1909.....	1,357	9,093	508	231	314	4,782	(*e*)86	141,858
1910.....	18,977	16,868	457	253	185	5,052	69	153,106
1911.....	19,070	19,737	632	233	201	3,666	55	150,974
1912.....	17,874	21,153	546	258	339	5,280	55	186,690
1913.....	19,125	31,590	299	255	157	5,216	175	130,526

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Year.	Quicksilver Kg.	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion. Kg.	Specie.		
1900.....	1,300	39,822	77,930	29,300	$199,955	.....	13,047
1901.....	2,600	39,625	83,401	41,800	207,669	.....	11,555
1902.....	1,300	46,128	92,617	177,900	237,104	.....	14,378
1903.....	1,600	48,793	94,492	150,400	250,299	.....	11,531
1904.....	2,500	94,103	97,364	36,700	420,413	.....	9,170
1905.....	2,400	.....	104,195	36,100	143,152	.....	8,852
1906(f).....	1,800	32,182	134,526	43,000	200,754	109,827	6,020
1907.....	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908.....	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909.....	2,600	75,397	183,189	150,980	172,201	155,812	6,915
1910.....	2,300	96,936	188,752	161,600	121,000	147,192	9,019
1911.....	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912.....	3,700	113,287	249,756	91,110	78,361	204,946	7,824
1913.....	4,400	110,923	235,775	148,580	206,032	214,726	6,351

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1900 ..	73	104	1,141	1,836	54,559	5,110	27,795
1901 ..	98	77	911	1,280	63,283	4,452	25,300
1902 ..	17	97	312	1,030	39,958	5,997	23,878
1903 ..	13	110	327	956	54,896	6,116	22,625
1904 ..	103	103	1,109	659	54,887	5,409	30,505
1905 ..	167	168	965	475	66,740	5,258	30,227
1906(f)	86	382	303	218	49,862	7,508	26,755
1907 ..	72	153	283	305	57,023	7,342	34,261
1908 ..	32	124	288	358	69,722	7,596	30,985
1909 ..	26	149	297	832	80,533	9,402	28,639
1910 ..	15	224	354	341	81,781	10,150	34,936
1911 ..	5	297	337	297	65,781	10,842	34,916
1912 ..	10	(i)455	260	302	92,838	14,454	40,913
1913 ..	12	247	262	102	93,025	12,682	39,228

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whet-stones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1900.....	10,643	3,439	3,643	14,181	17,844	667	875
1901.....	11,712	3,671	3,445	18,403	16,921	579	718
1902.....	12,474	3,638	3,599	20,723	17,034	651	636
1903.....	16,148	3,564	3,774	22,344	17,973	746	698
1904.....	19,878	3,528	4,272	24,039	20,787	731	840
1905.....	17,320	3,845	4,376	22,890	21,874	568	972
1906(f).....	17,020	3,320	4,377	24,014	19,467	595	347
1907.....	20,430	4,433	5,552	24,289	24,092	604	219
1908.....	25,251	4,295	5,916	19,366	26,472	1,010	361
1909.....	27,368	4,587	6,826	24,639	27,148	1,263	349
1910.....	27,421	4,674	6,915	30,880	29,168	1,898	511
1911.....	26,630	4,795	8,066	31,357	33,740	388	471
1912.....	36,714	4,806	6,826	35,376	37,558	1,260	438
1913.....	24,922	4,214	6,579	52,299	31,841	1,264	392

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate.

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MINERAL EXPORTS OF AUSTRIA-HUNGARY (a)
(In metric tons or dollars; 5 crowns = $1)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic Oxide, Orpiment, and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1900	44	164	247	276	65	47	168	1,218	2,177
1901	55	211	179	385	80	36	165	198	1,909
1902	102	135	174	290	89	65	275	520	301
1903	77	14	128	249	63	89	495	921	483
1904	38	2	200	673	72	290	1,582	403	728
1905	68	34	178	774	42	330	1,397	1,060	457
1906 (f).	68	80	314	912	66	376	1,708	2,824	799
1907	75	81	92	698	59	351	630	3,787	771
1908	147	92	161	527	51	442	450	1,312	1,030
1909	65	57	97	185	117	264	561	1,800	758
1910	346	85	54	416	9	262	604	1,545	954
1911	157	16	77	267	13	141	992	1,845	1,218
1912	253	7	54	689	2	530	779	1,357	1,920
1913	454	5	.....	.....	.....	243	1,605	326	2,621

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (b)	Chloride.					Bituminous.	Lignitic.	
1900 ...	23	.....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901 ...	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902 ...	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903 ...	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904 ...	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905 ...	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906(f)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907 ...	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908 ...	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909 ...	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910 ...	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911 ...	12	3,741	1,175	168,321	70	174,493	609,737	7,063,981	299,915
1912 ...	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913 ...	753	4,918	2,042	144,596	142	197,693	708,975	7,016,606	369,802

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets, Plates, etc.			
1900.....	45.0	801	471	200	57	748	237
1901.....	6.0	1,042	435	334	23	548	231
1902.....	42.0	1,018	436	381	44	857	363
1903.....	12.0	1,308	1,226	451	45	898	521
1904.....	36.0	574	747	577	50	1,170	574
1905.....	5.0	2,328	1,253	746	49	836	638
1906.....	*Nil.*	341	1,007	816	99	861	*Nil.*
1907(f).....	*Nil.*	489	624	870	11	1,580	*Nil.*
1908.....	7.0	206	1,126	791	63	2,199	*Nil.*
1909.....	12.0	136	1,250	541	40	1,877	*Nil.*
1910.....	4.0	101	977	700	83	2,273	42
1911.....	0.2	126	1,309	1,109	14	2,124	122
1912.....	13.0	516	1,332	1,642	119	3,090	46
1913.....	15.0	182	1,379	1,297	172	2,653	.....

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Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (c)	Specie. (c)		Crude.	Calcined.	
1900	1	$120,988	$11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	.....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1,059	9,338	10,995,089	18,535	363	1,652	4,085
1906	936	88,264	8,015,967	16,871	1,970	686	2,942
1907(f)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(h)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(h)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1900	263,421	53,426	40,344	65,019	86,273	7,321	(c)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906(f)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,666
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	21,148	.....	.....	678,194	2,151	200,947

Year.	Lead.						Manganese Ore	Millstones.	Mineral Paints.	Nickel and Cobalt Ores.
	Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.				
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	26
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906(f)	4,891	223	302	602	16	52	4,170	1,763	1,367	42
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	*Nil.*
1909	5,711	294	343	306	125	80	787	3,849	2,577	*Nil.*
1910	6,163	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	.....	28	548	19	82	534	3,530	4,272	0.3
1913	2,828	.....	36	1,060	3	32	550	3,083	3,831	4.0

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Year.	Nitric Acid.	Ozokerite.	Peat and Peat Coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1900....	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901....	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902....	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903....	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904....	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905....	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906(f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,983	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,889	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,160	1,370	3,885	312

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1900...	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901...	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902...	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903...	8,389	292	111	158	2,589	15,108	4,420	729	3,446	267
1904...	9,101	126	102	123	2,159	17,314	4,606	532	3,656	158
1905...	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906(f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,591	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(g)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(g)
1912...	16,216	(i)1,038	42	.....	1,414	14,539	(i)10,356	2,483	5,890	.....
1913...	14,902	1,061	32	.....	1,358	16,376	13,174	1,383	5,514	.....

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets*. (b) Includes artificial barium sulphate. (c) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (d) From 1895 to 1898, inclusive, includes crude and refined petroleum; from 1899 to 1905, inclusive, lubricating oil is also included. (e) Where gold or silver values are reported, 1 crown = $0.203. (f) Last 10 months only. (g) Not reported. (h) Values in gold, $40,200 and $38,760. (i) Includes dross.

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BELGIUM

Figures in full-faced type are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM (a)

(In metric tons except where otherwise noted)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthenware.	
1903....	21,000	1,580,330	23,796,680	1,686,415	2,428,020	16,250	184,400
1904....	60,000	1,645,655	(e)22,761,430	1,735,480	2,496,340	18,070	206,730
1905....	26,000	1,493,745	21,775,280	1,711,920	2,526,690	12,800	176,620
1906....	22,365	1,521,660	23,569,860	1,887,090	2,712,760	14,900	232,570
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910....	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	22,841,590	2,608,640	3,523,000	16,690	150,450
1914....	.....	1,051,160	16,714,050	1,799,700	2,001,670	5,400	82,360
1915....	.....	278,975	14,177,500	1,490,100	514,600	.....	4,720
1916....	.....	567,240	16,862,870	1,935,820	792,350	350	30,430
1917....	.....	374,380	14,931,340	981,930	676,040	.....	17,000

Year.	Iron, Crude.					Iron and Steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel.	Merchant Bars.	Beams & Special Bars.	Tires.
1903....	91,600	256,890	229,160	638,430	1,216,080	969,230	446,360	138,270	17,810
1904....	99,350	224,410	217,390	742,040	1,287,597	1,065,870	543,260	268,360	23,540
1905....	98,170	206,390	220,210	784,850	1,311,120	1,200,430	570,130	299,840	25,810
1906....	96,090	218,225	177,900	870,860	1,375,775	1,440,880	552,850	346,420	32,070
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,450
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,320
1913....	93,830	66,370	32,260	2,291,390	2,484,690	2,466,630	855,550	213,940	34,140
1914....	60,310	28,660	44,390	1,316,450	1,454,400	1,396,300	489,360	131,860	15,150
1915....	26,260	3,150	14,730	19,780	68,150	98,320	76,670	9,555	2,930
1916....	58,805	17,040	17,400	36,540	127,825	99,371	121,765	12,630	2,630
1917....	.....	.....	2,460	5,530	7,990	9,530	44,510	4,730	750

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Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.	
1903	(c)351,540	113,830	74,030	1,376,630	90	68,700	6,100
1904	(c)266,900	126,960	79,040	1,378,750	91	(f)23,470	485
1905	241,640	167,240	76,510	1,469,020	126	22,885	*Nil.*
1906	274,920	166,970	84,150	1,522,995	121	23,765	120
1907	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908	(c)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910	347,890	177,110	122,930	1,834,050	162	40,715	*Nil.*
1911	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913	341,870	241,200	138,570	2,162,210	132	53,590	*Nil.*
1914	152,750	160,640	81,900	1,238,780	52	45,560	*Nil.*
1915	29,470	16,895	20,970	164,370	121	16,770	500
1916	9,730	26,205	40,490	223,335	91	15,560	3,870
1917	730	10,360	12,660	75,150	35	22,745	2,020

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore (Blende).	Ore (Calamine).	Spelter.	Sheets.
1903	200	184,120	720	38,953,000	232,740	3,565	65	131,740	42,280
1904	150	202,480	1,075	41,240,000	252,920	3,698	4	137,323	41,490
1905	300	193,305	976	41,435,000	201,935	3,929	*Nil.*	142,555	45,320
1906	250	152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	.....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,230	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	268	27,390,000	253,940	949	*Nil.*	204,220	51,490
1914	300	105,330	109	16,430,000	141,590	410	.....	145,925	30,780
1915	.....	16,350	129	16,480,000	33,650	796	.....	51,660	21,350
1916	.....	77,740	212	19,460,000	41,060	602	.....	22,930	8,045
1917	.....	138,300	81	2,270,000	10,490	231	.....	10,290	1,675

(a) From *Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique* (c) Includes beams. (e) Net production from this year on. (f) Domestic lead only, beginning with this year.

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CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA (*a*)
(In metric tons or dollars)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement. *Barrels.* (*j*)		Chromite.	Coal.	Cobalt and Oxide.	Coke. (*k*)
				Natural Rock.	Portland.				
1905....	*Nil.*	61,928	3,049	14,184	1,346,547	7,781	7,961,397	.....	622,154
1906....	*Nil.*	72,025	3,628	8,610	2,139,164	7,936	9,033,973	.....	(*b*)
1907....	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	.....	(*b*)
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(*b*)	*Nil*	4,067,709	2,240	9,526,938	(*i*)	782,016
1910....	1,362	92,800	(*b*)	*Nil*	4,753,975	276	11,711,000	(*i*)	818,450
1911....	1,902	115,136	45	*Nil*	5,692,915	143	10,243,528	(*i*)	848,280
1912....	1,855	123,679	421	*Nil*	7,132,732	(*b*)	13,168,941	(*i*)	1,275,829
1913....	1,535	146,169	581	*Nil*	8,658,805	(*b*)	13,622,070	(*i*)	1,376,646
1914....	1,576	106,686	555	*Nil*	7,172,480	123	12,336,088	(*i*)	921,241
1915....	2,174	124,123	499	*Nil*	5,681,032	11,196	12,035,843	229	1,089,335
1916....	1,983	139,844	1,241	*Nil*	5,369,560	24,962	13,139,336	381	1,314,335
1917....	2,663	139,510	3,166	*Nil*	4,768,488	33,317	12,743,220	490	1,117,548
1918....	3,173	143,515	581	*Nil*	3,591,481	19,953	13,589,142	611	1,119,800

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (*c*)	Graphite.	Grindstones.	Gypsum.	Iron Ore. (*d*)	Iron, Pig. All kinds.
1905..	21,596	1,492	10,617	$14,486,833	491	4,693	395,341	263,113	475,491
1906..	25,863	2,063	14,397	12,023,932	405	5,029	378,904	269,842	550,628
1907..	26,025	1,716	11,414	8,264,765	525	4,881	431,286	283,820	590,444
1908..	28,895	988	7,144	9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	243,167	(*g*) 686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	235,342	(*g*) 726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	(*g*) 832,376
1912..	35,314	1,778	12,461	12,648,794	1,869	4,003	524,892	107,190	(*g*) 920,636
1913..	34,926	1,068	15,235	16,598,923	1,962	4,389	577,442	196,558	(*g*) 1,024,424
1914..	34,364	507	16,388	15,925,044	1,494	3,700	463,375	54,816	(*g*) 710,675
1915..	45,717	238	13,208	18,976,218	2,390	2,341	430,752	81,403	(*g*) 828,977
1916..	53,139	61	17,680	19,234,976	3,588	3,155	311,092	127,560	(*g*) 1,060,750
1917..	49,544	171	18,773	15,272,992	(*l*) 3,866	2,289	305,120	153,545	(*g*) 1,063,047
1918..	53,712	124	18,354	14,687,875	2,768	2,787	138,155	102,410	1,077,160

Year.	Steel. (*h*)	Lead. (In ore, etc.)	Magnesite.	Manganese Ore.	Mica.	Mineral Paints. (Ochers)	Molybdenite. (MoS_2 Content)	Natural Gas.
1905.....	409,930	25,391	.....	(*d*) 20	$168,170	4,632	.....	$314,249
1906.....	580,060	24,580	.....	(*d*) 84	(*d*) 581,043	6,201	.....	528,868
1907.....	641,374	21,570	.....	.....	333,022	7,115	.....	748,541
1908.....	534,117	19,593	109	.....	139,871	4,305	.....	1,012,660
1909.....	684,670	20,801	299	.....	147,782	3,573	.....	1,207,029
1910.....	745,963	14,953	293	.....	190,385	4,365	.....	1,346,471
1911.....	800,510	10,617	899	5	128,667	3,285	.....	1,917,673
1912.....	868,808	16,227	1,555	68	143,976	6,945	.....	2,362,700
1913.....	1,060,510	17,089	467	0	194,304	5,432	.....	3,309,381
1914.....	751,743	19,888	325	25	109,061	5,345	2	3,484,727
1915.....	926,157	21,009	13,407	182	91,905	5,668	13	3,706,035
1916.....	1,295,707	18,823	50,261	868	255,239	7,993	71	3,958,029
1917.....	1,583,786	14,776	52,699	143	(*m*) 358,851	8,536	131	5,045,298
1918.....	1,717,390	19,888	35,712	711	268,375	15,710	171	4,370,622

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Year.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (*e*)	Phosphate. (Apatite.)	Pyrite.	Salt.	Silver. *Kg.* (In ore, etc.)	Soapstone and Talc.
1905.....	8,565	634,095	1,180	29,713	41,159	185,839	454
1906.....	9,745	569,753	(*b*)	35,927	69,283	266,521	1,119
1907.....	9,610	788,872	680	35,494	65,936	390,359	1,391
1908.....	8,685	527,987	1,447	42,934	72,537	687,504	976
1909.....	11,922	420,755	905	58,645	76,237	856,263	3,945
1910.....	16,905	315,895	1,341	48,871	76,286	1,022,350	6,450
1911.....	15,457	291,092	563	74,978	83,065	1,012,586	6,621
1912.....	20,346	243,336	149	73,976	86,248	993,952	7,504
1913.....	22,539	228,080	349	143,882	91,457	990,538	11,115
1914.....	20,652	214,805	866	204,125	97,126	856,741	9,807
1915.....	30,985	215,464	197	259,494	108,773	828,067	10,782
1916.....	37,629	198,123	184	280,553	120,570	791,874	11,888
1917.....	37,344	213,832	135	377,984	126,018	691,148	14,336
1918.....	41,765	304,741	127	375,307	119,503	662,015	16,502

(*a*) From *Annual Report on the Mineral Production of Canada*, Department of Mines; latest year from *Preliminary Report*. (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*g*) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, 36,355 tons in 1912, 73,508 tons in 1913, 95,744 in 1914, 158,595 short tons in 1915 and 115,691 short tons in 1916. (*h*) Steel ingots and castings. (*i*) 1909, $94,609; 1910, $51,986; 1911, $221,790; $320,244 in 1912, $695,855 in 1913; $678,619 in 1914, for oxides of cobalt and nickel; values received. (*j*) Bbl. of 350 lb. each, sold or shipped. (*k*) Including that from foreign coal. (*l*) Including 497 tons of artificial graphite. (*m*) 1058 tons.

MINERAL IMPORTS OF THE DOMINION OF CANADA (*a*)

(In metric tons or dollars)

Year. (*b*)	Aluminium.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures. (*m*)	Ingots, Sheets, etc.					
1906.....	$23,565	$168,405	183	202	$138,000	7,178	$1,003,022
1907(*o*).....	20,656	218,399	146	158	127,509	11,929	540,006
1908(*r*).....	37,197	131,762	220	228	191,204	14,113	865,275
1909(*r*).....	30,076	167,019	201	58	181,710	15,979	473,211
1910(*r*).....	42,493	424,006	232	12	198,756	19,661	159,040
1911(*r*).....	83,638	782,254	257	115	254,331	23,248	(*i*)494,446
1912(*r*).....	119,070	487,490	233	159	349,655	28,291	(*i*)936,425
1913(*r*).....	126,531	403,700	400	259	497,160	47,353	(*i*)1,955,177
1914(*r*).....	151,261	730,012	322	127	474,499	48,564	(*i*)352,134
1915(*r*).....	87,242	672,527	733	8	226,515	38,175	(*i*)132,492
1916(*r*).....	85,574	700,365	595	146	191,886	38,029	45,295
1917(*r*).....	197,950	349,455	278	126	394,540	29,246	29,719
1918(*r*).....	224,449	318,444	216	199	528,054	18,229	17,417
1919(*r*).....	287,387	114,756	239	100	649,694	18,804	26,437

Year.	Coal.		Coke.	Copper.	Copper Sulphate.	Gold and Silver.
	Anthracite. (*f*)	Bituminous. (*f*)		Ingots, Pig, and Scrap.		Coin and Bullion. (*g*)
1906.....	1,996,183	5,003,029	435,561	1,191	844	$7,078,603
1907(*o*)....	1,260,723	4,022,843	363,286	1,186	897	7,029,047
1908(*r*)....	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
1909(*r*)....	2,775,680	6,526,797	423,013	1,239	963	9,988,442
1910(*r*)....	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1911(*r*)....	3,144,130	7,785,259	692,292	2,279	772	10,206,210
1912(*r*)....	3,736,169	9,526,138	582,331	2,514	930	26,033,881
1913(*r*)....	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
1914(*r*)....	3,979,674	12,479,959	643,693	2,511	606	15,235,317
1915(*r*)....	3,971,968	8,279,570	460,381	2,053	335	131,993,031
1916(*r*)....	4,429,143	9,631,101	693,607	1,689	862	34,260,202
1917(*r*)....	4,144,488	11,730,145	686,389	2,308	921	28,081,120
1918(*r*)....	4,768,510	14,878,080	880,455	2,441	1,266	12,293,901
1919(*r*)....	3,511,710	15,031,419	988,855	1,921	1,146	.....

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Year.	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures.	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc. (x)	Alloys of Iron.
1906.....	$2,791	$86,028	5,743	6,579	112,937	29,520	13,626
1907(o).....	3,176	57,430	8,334	9,730	137,654	17,369	17,785
1908(r).....	3,030	78,380	8,519	6,955	190,994	35,534	16,139
1909(r).....	1,408	75,608	9,359	7,712	62,967	43,263	13,571
1910(r).....	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911(r).....	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912(r).....	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913(r).....	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914(r).....	3,689	71,340	4,877	15,084	251,730	145,731	26,256
1915(r).....	1,464	43,313	3 236	5,769	69,261	50,086	2,534
1916(r).....	3,620	48,614	1,658	2,222	55,171	118,589	12,761
1917(r).....	3,008	102,960	3,069	3,548	70,482	73,270	12,069
1918(r).....	121,485	112,849	159	2,596	90,233	60,147	13,146
1919(r).....	21,203	142,698	213	986	118,782	51,468	31,157

Year.	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride.	
1906...	306	3,751	730	461	6,947	134,334	2,645	809
1907(o)	511	3,811	622	513	2,215	88,919	2,302	570
1908(r)	743	2,902	782	864	5,743	129,379	3,421	788
1909(r)	562	2,273	623	550	3,998	153,934	2,697	546
1910(r)	687	5,755	580	915	4,433	191,527	4,554	914
1911(r)	339	5,292	707	750	5,312	176,730	4,745	1,169
1912(r)	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913(r)	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914(r)	180	5,078	654	512	7.547	.....	6,264	1,605
1915(r)	350	7.539	358	479	5,350	.....	2,446	1,282
1916(r)	44	22,928	477	1,043	6,090	.....	4,973	1,162
1917(r)	174	5,473	450	1,147	7,274	.....	3,670	1,774
1918(r)	355	5,564	429	1,081	7,471	.....	3,428	1,851
1919(r)	80	4,619	372	835	8,198	.....	5,505	1,439

Year.	Nickel. (s)	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Mineral Oil, etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1906.....	$15,976	10,981,611	375	$54,494	1,317	1,141	68
1907(o).....	19,461	8,066,403	189	113,967	1,074	638	44
1908(r).....	.....	8,844,129	102	63,582	3,396	2,653	81
1909(r).....	67,107	13,095,593	103	47,371	1,570	925	42
1910(r).....	98,238	(u)48,284,763	253	80,180	2,497	665	129
1911(r).....	137,114	(u)66,119,105	931	136,823	3,152	1,490	59
1912(r).....	135,227	88,916,283	808	190,770	3,734	1,049	49
1913(r).....	194,079	164,013,894	892	221,300	5,643	835	67
1914(r).....	144,343	202,540,731	717	121,336	8,057	776	115
1915(r).....	172,037	211,900,141	623	65,008	4,139	1,034	67
1916(r).....	239,495	213,670,889	549	100,415	1,706	850	83
1917(r).....	402,831	301,775,484	537	83,409	402	277	39
1918(r).....	293,611	384,572,804	1,004	98,507	125	425	41
1919(r).....	225,463	437,476,494	811	28,010	240	340	15

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Year.	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts, Except Chloride.	Sulphur.	Tin and Tin-ware.	Zinc.
1906	209	99,788	338	30,401	19,512	$3,105,876	3,383
1907(o)	130	73,156	542	25,068	11,725	2,473,572	2,761
1908(r)	172	105,286	1,131	39,154	23,494	1,619,647	2,521
1909(r)	162	119,660	417	33,787	19,981	2,984,065	2,993
1910(r)	303	121,473	582	47,913	19,484	3,512,615	(v)7,606
1911(r)	346	111,174	468	62,969	22,935	4,235,848	(v)6,069
1912(r)	377	119,114	337	74,016	20,430	3,710,102	7,217
1913(r)	544	100,494	658	98,561	32,984	3,055,943	9,397
1914(r)	356	132,777	755	100,701	27,093	6,350,610	7,402
1915(r)	430	121,683	582	78,894	39,412	4,783,108	7,230
1916(r)	420	125,804	402	96,321	34,411	5,312,847	7,357
1917(r)	351	143,778	1,608	116,764	76,179	10,317,431	7,251
1918(r)	487	160,352	744	127,111	67,443	15,241,179	8,649
1919(r)	314	147,977	54	139,840	88,286	15,131,175	5,688

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year. (b)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper. (c)
1906	388	40,367	1,640	1,651,203	50,004	20,082
1907(o)	832	37,194	604	1,165,809	44,669	11,845
1908(r)	693	53,543	1,585	1,702,673	50,343	25,824
1909(r)	1	54,188	3,707	1,548,468	70,024	24,642
1910(r)	33	58,083	1,052	1,822,398	44,343	26,107
1911(r)	222	63,348	14	2,100,309	54,380	24,950
1912(r)	1	69,233	.....	1,436,798	13,677	25,595
1913(r)	.....	83,299	.....	1,920,809	56,271	36,717
1914(r)	.....	96,159	.....	1,360,029	66,512	37,772
1915(r)	306	67,968	72	1,372,431	47,978	28,438
1916(r)	970	80,611	10,649	1,788,679	39,737	52,995
1917(r)	609	87,086	11,944	1,722,941	35,290	61,265
1918(r)	604	89,503	15,805	1,725,503	23,599	53,824
1919(r)	51	113,727	14,188	1,657,127	24,468	53,094

Year.	Gold, Quarts, Dust, etc.	Graphite.	Grindstones.	Gypsum, Crude.	Iron Ore.	Lead. (p)
1906	$12,991,916	180	$15,793	367,203	134,270	6,158
1907(o)	7,226,954	3	33,929	249,780	31,011	8,330
1908(r)	8,817,041	167	28,726	340,235	23,863	12,650
1909(r)	7,392,610	396	18,019	239,139	3,568	5,459
1910(r)	6,110,473	1,164	13,754	304,736	28,608	8,395
1911(r)	5,344,465	362	23,914	325,928	95,080	1,451
1912(r)	7,211,438	1,395	30,513	324,324	34,162	52
1913(r)	11,231,476	1,572	27,375	344,183	123,004	93
1914(r)	13,326,755	1,367	54,584	359,287	103,126	125
1915(r)	15,406,510	451	45,889	292,800	198,412	328
1916(r)	16,870,394	366	19,971	348,923	75,212	1,406
1917(r)	19,671,026	180	36,646	205,575	155,773	7,924
1918(r)	13,688,700	65	29,767	182,320	143,258	7,343
1919(r)	9,202,033	573	48,947	62,628	119,470	11,497

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Year.	Manganese Ore.	Mica.	Nickel. (y)	Petroleum, Crude and Refined.	Pyrites.	Salt. *Bushels.* (w)	Silver (in Ore, Bullion, etc). *Kg.*
1906	15	603	10,866	1,741	18,398	23,168	203,323
1907(o)...	84	631	7,355	(q)3,167	20,148	5,113	274,178
1908(r)...	1	409	8,596	(q)3,389	17,835	35,543	515,161
1909(r)...	3	243	8,895	(q)195	23,087	3,040	733,248
1910(r)...	5	397	13,391	(q)9,093	24,439	6,088	932,098
1911(r)...	2	370	15,771	(q)1,493	32,396	6,625	1,049,153
1912(r)...	12	348	15,073	38,663	25,279	109,963	960,586
1913(r)..	7	415	21,849	152,746	3,109	60,536	1,096,835
1914(r).....	.....	321	22,949	(q)25,443	42,006	6,165	1,143,337
1915(r)...	82	387	20,604	(q)18,376	87,021	15,865	788,656
1916(r)...	489	392	31,912	(q)512,443	131,598	9,227	864,527
1917(r) .	581	608	37,476	(q)238,875	137,038	10,082	741,657
1918(r)...	143	544	37,671	(q)93,174	254,122	102,173	683,048
1919(r)...	711	319	35,755	(q)3,324,464	215,534	26,573	614,580

(a) From Tables of the *Monthly Report of the Trade of Canada.* (b) Fiscal year ending June 30. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (m) Unclassified. (n) Includes chromic iron ore. (o) Returns for the 9 months of the fiscal year ending March 31. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821, 247,940, 35,431, and 14,370 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lb. per bushel. (x) Does not include rolled, cast, or forged material. (y) Includes nickel in ore, matte, etc.

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CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA (*a*)

(In metric tons)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Petroleum. *Gal.*	Quicksilver.	Tin.	Tinplate.	Zinc.	
									Spelter.	Sheet, etc.
1911...	1,244	4,408	8,138	39	235,898,240	49	1,994	21,676	81	769
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861
1913...	1,628	12,144	6,511	109	183,984,052	40	3,566	21,983	529	1,971
1914...	1,646	17,461	7,093	61	225 464,201	21	3,922	25,369	509	851
1915...	802	2,131	5,681	66	185,070,111	11	2,503	24,066	17	61
1916...	693	2,375	5,121	126	147,396,436	22	3,137	21,006	40	379
1917...	.....	2,532	5,205	.....	157,929,202	.....	2,866	.....	.....	.....

MINERAL EXPORTS OF CHINA (*a*)

(In metric tons)

Year.	Antimony.		Iron.		Lead.		Quicksilver.	Tin.	Zinc.	
	Ore.	Metal.(*b*)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1911.....	6,812	6,986	112,295	70,906	5,410	11	18.5	6,056	4,599	710
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760
1913.....	4,351	13,032	274,064	64,811	4,066	42	2.1	8,390	9,550	908
1914.....	4,972	19,645	299,515	60,068	3,722	235	59.7	7,215	7,374	310
1915.....	1,373	23,357	308,973	96,537	57	687	40.7	8,006	8,541	2,328
1916.....	12,958	24,740	311,932	159,475	9,899	1,244	177.7	8,403	452	803
1917.....	4,254	38,539	340,878	162,194	13,953	825	254.0	13,038	251	476

(*a*) From annual reports of the Imperial Chinese Maritime Customs. (*b*) Regulus and refined.

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FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE (*a*)
(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (*c*)	Cement.
		Ore.	Metal.						
1901.....	1,200	9,867	1,786	7,491	20,391	4,145	76,620	249,655	1,127,206
1902.....	1,355	9,715	1,725	5,372	.....	4,323	96,900	258,295	962,930
1903.....	1,570	12,380	2,748	6,658	.....	5,731	133,890	243,295	898,393
1904.....	1,650	9,065	2,116	3,117	22,000	6,944	75,640	227,177	903,632
1905.....	1,905	12,543	2,396	3,627	20,000	5,504	103,207	188,403	922,531
1906.....	3,396	18,567	3,433	6,534	38,231	11,680	117,781	196,375	1,257,861
1907.....	4,700	24,000	3,950	7,900	33,000	11,150	158,000	177,000	1,253,546
1908.....	4,681	26,026	3,850	2,381	41,000	16,277	170,679	171,158	1,359,658
1909.....	6,092	28,105	5,444	2,141	44,800	14,111	130,149	169,000	1,374,574
1910.....	6,425	28,130	4,640	8,045	38,500	11,632	196,056	169,769	1,521,131
1911.....	7,400	29,267	4,775	19,000	39,000	10,064	254,831	170,000	1,795,000
1912.....	10,200	11,018	(*i*)5,406	81,880	31,535	13,620	258,929	312,000	1,924,277
1913.....	13,483	17,036	6,390	70,613	30,892	12,236	309,294	324,601	1,930,066

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1902.....	29,365,047	632,423	109,941	828	6,300	(*b*)	219,487	1,572,687
1903.....	34,217,661	688,757	100,348	10,892	6,921	(*b*)	162,766	1,468,330
1904.....	33,502,394	665,572	95,716	2,756	6,900	(*b*)	106,173	1,481,303
1905.....	35,218,000	709,000	98,500	5,068	7,576	$235,447	78,832	1,299,313
1906.....	33,458,000	738,000	92,469	2,547	5,770	511,665	79,568	1,297,861
1907.....	35,989,000	765,000	90,952	2,400	7,800	847,290	87,370	1,316,567
1908.....	36,633,000	751,000	79,759	766	7,935	960,666	92,898	1,326,131
1909.....	37,115,500	724,500	78,600	458	7,823	1,147,400	76,057	1,263,692
1910.....	37,634,893	715,000	48,415	222	12,933	(*h*) 1,706,580	64,181	1,533,298
1911.....	38,521,000	709,000	58,521	35	13,200	(*h*) 1,463,519	59,648	1,640,698
1912.....	41,145,000	751,000	43,000	242	11,907	1,998,620	25,900	1,700,000
1913.....	40,050,888	793,330	44,878	521	11,968	153,009	66,218	.....

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig	Wrought Iron.	Wrought Steel.	Ore. (*d*)	Pig. (*e*)			
1902.	5,003,782	2,405,000	639,600	1,245,800	22,634	19,000	4,796,807	12,536	34,504
1903.	6,219,541	2,840,517	598,910	1,305,709	23,080	23,258	4,727,543	11,583	35,031
1904.	7,022,841	2,999,787	554,632	1,482,708	14,173	18,800	4,583,522	11,254	37,409
1905.	7,395,409	3,077,000	670,000	1,442,000	12,118	24,100	3,694,725	6,751	33,468
1906.	8,481,423	3,314,100	747,900	1,683,500	11,795	25,614	3,869,772	11,189	32,407
1907.	10,008,000	3,590,000	579,900	1,860,000	18,000	24,800	2,438,409	18,200	30,480
1908.	10,057,145	3,400,700	560,200	1,851,900	13,403	26,112	2,535,833	15,865	30,522
1909.	11,890,000	3,573,848	558,000	2,040,364	13,794	26,927	2,211,653	9,378	30,503
1910.	14,605,542	4,038,000	526,000	2,324,000	14,536	20,226	2,110,540	7,925	32,461
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,939,194	525,000	4,403,688	13,953	31,086	3,807,596	5,576	33,751
1913.	21,918,000	5,207,307	405,972	4,686,866	17,081	28,817	2,838,392	7,732	29,994

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Year.	Mineral Paints. (Ochers)	Nickel.	Phosphate Rock.	Pyrite.	Salt.	Silver. *Kg.*	Sulphur Ore. (*g*)	Zinc.	
								Ore.	Metal.
1901....	35,704	1,800	535,676	307,447	910,000	.....	7,000	61,539	37,600
1902....	34,770	1,600	543,900	318,235	863,927	.....	8,021	57,982	36,300
1903....	34,042	1,500	475,783	322,118	967,531	.....	7,375	66,922	37,416
1904....	34,945	1,500	423,521	271,544	1,153,754	.....	5,447	52,842	41,600
1905....	37,800	1,800	476,720	267,114	1,162,100	.....	4,637	62,150	43,200
1906....	35,550	1,750	469,408	265,261	1,388,500	50,058	2,713	53,466	46,536
1907....	32,856	1,500	432,237	283,000	1,324,000	47,009	2,000	44,000	47,900
1908....	33,060	1,800	485,607	284,717	1,173,000	61,184	2,189	52,611	47,880
1909....	33,540	1,600	397,908	273,221	1,113,000	63,671	2,900	96,903	49,958
1910....	32,870	2,100	333,506	250,432	1,051,427	52,957	2,641	50,624	52,590
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,111
1912....	41,810	1,725	313,151	282,202	1,099,000	63,736	1,000	45,929	62,650
1913....	56,240	1,500	298,859	311,167	1,281,978	31,268	659	46,577	67,896

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur. (*h*) From ores. (*i*) Regulus and oxide.

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt. Ore.	Copper Ore.	Nickel. Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1904.....	42,197	8,964	*Nil.*	98,655	1911...	35,000	*Nil.*	1,900	142,000
1905.....	51,374	7,920	*Nil.*	125,289	1912(*c*)	51,516	*Nil.*	(*d*)	74,312
1906	84,211	2,600	207	118,890	1913(*c*)	63,370	.....	.....	164,406
1907	57,367	29,800	437	119,000	1914...	42,000	(*e*)945	.....	94,154
1908	25,371	2,360	(*b*) 10	108,000	1915...	57,474	.....	.....	48,476
1909	40,000	548	9,600	86,000	1916(*c*).	74,115	.....	.....	(*e*)35,614
1910	40,000	54	8,000	99,000	1917(*c*).	41,892	.....	.....	(*e*)32,017

(*a*) From *Statistique de l'Industrie Minérale.* (*c*) Exports, *Echo des Mines.* (*d*) Copper matte worth $101,000. (*e*) Includes matte.

MINERAL IMPORTS OF FRANCE (*a*) (*k*)

(In metric tons or dollars. 5 f. = $1)

Year.	Alum-inium.	Bitu-men. (*f*)	Borax.	Bro-mides.	Cement.	Coal and Coke.	Copper.		Copper.	
							Ore.	Ingot and Mfrs.	Sulphate.	Oxide.
1903....	.....	27,573	312	9	21,152	14,029,687	9,796	59,126	25,428	129
1904....	.....	17,178	3,113	17	21,702	13,936,475	9,942	69,183	30,856	142
1905....	.....	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	.....	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	.....	31,700	.....	.....	24,839	18,706,000	12,063	76,282	.....	.....
1908....	.....	48,000	.....	.....	31,550	18,563,000	15,300	86,985	.....	.....
1909....	.....	54,000	.....	.....	46,664	19,387,000	27,400	86,143	.....	.....
1910....	.....	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	.....	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	.....	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	.....	.....	.....	.....	.....	.....	9,653	.....	.....	.....
1914....	.....	.....	.....	.....	.....	17,637,149	.....	89,140	.....	.....
1915....	.....	.....	.....	.....	.....	19,693,599	.....	126,127	.....	.....
1916....	739	.....	.....	.....	.....	20,213,833	1,591	175,009	.....	.....
1917....	1,350	.....	.....	.....	.....	.....	4,030	249,138	.....	.....
1918....	7,219	.....	.....	.....	.....	.....	427	166,781	.....	.....

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Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfrs.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap, and Mfrs.
1903....	.....	1,832,820	61,085	119,799	36	1,207	47,534	20,172	2,040	75,416
1904....	.....	1,738,514	38,521	125,709	319	1,151	50,465	25,731	2,221	76,198
1905....	.....	2,151,954	121,726	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	.....	2,015,550	135,252	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	122,102	336,337	.....	.....	53,447	42,342	.....	53,359
1908....	1,500	1,454,000	156,618	373,624	.....	.....	58,909	40,700	.....	70,824
1909....	400	1,202,619	154,031	354,428	.....	.....	59,490	38,400	.....	68,332
1910....	2.6	1,318,520	168,810	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	194,225	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	.....	1,454,190	36,637	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	.....	.....	49,612	.....	.....	.....	61,255	39,772	.....	.....
1914....	.....	1,044,160	57,241	.....	.....	.....	.....	.....	.....	41,900
1915....	.....	397,348	.....	1,133,898	.....	.....	.....	.....	.....	51,700
1916....	.....	824,176	.....	2,897,553	.....	.....	.....	40,750	.....	63,739
1917....	.....	.....	.....	.....	.....	.....	.....	36,027	.....	57,846
1918....	.....	.....	.....	.....	.....	.....	.....	24,128	.....	51,441

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (*h*)
1903	919	109,930	13,933	427	(*g*)476,230	343,012	3,764	12,275	2,760
1904	1,679	105,652	20,698	313	(*g*)435,730	419,720	5,650	14,734	2,618
1905	406	140,871	49,698	632	(*g*)512,727	447,738	4,023	21,819	2,619
1906	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907	.....	192,448	45,892	979	(*g*)311,000	636,549	4,373	.....	.....
1908(*k*)..	.....	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	.....	.....
1909(*k*)..	.....	177,314	12,200	.....	(*g*)300,000	645,178	5,914	.....	.....
1910	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913	.....	258,929	10,292	.....	.....	934,679	.....	.....	.....
1914	.....	.....	.....	3,174	(*g*)488,555	661,429	.....	.....	.....
1915	.....	.....	.....	3,892	472,696	325,114	.....	.....	.....
1916	.....	58,658	8,915	1,760	658,589	285,906	.....	.....	.....
1917	.....	77,356	5,152	1,871	.....	.....	.....	.....	.....
1918	.....	59,296	3,289	823	.....	.....	.....	.....	.....

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Sal Ammoniac.	Salt.	Sodium.	
	Nitrate.	Carbonate.		Ore.	Metal.			Hydrate.	Nitrate.
1903	1,530	3,019	205,322	20	220	12,462	48,556	781	10,810,775
1904	2,117	3,781	230,097	22	208	13,744	46,232	1,068	9,074,859
1905	1,022	3,542	271,684	.....	228	11,639	45,241	860	11,336,752
1906	684	2,206	349,514	.....	242	18,146	38,361	614	13,678,848
1907	.....	.....	355,300	.....	216	.....	30,000	.....	.....
1908(*k*) ..	.....	.....	348,300	.....	180	.....	33,000	.....	.....
1909(*k*) ..	.....	.....	275,600	.....	191	.....	30,000	.....	.....
1910	132	2,579	309,400	.....	146	27,860	49,800	577	345,160
1911	174	4,452	318,530	.....	196	23,200	47,200	550	317,725
1912	53	4,017	486,072	.....	213	25,056	39,500	556	354,776
1913	.....	.....	186,348	.....	.....	.....	.....	.....	322,115
1914	.....	.....	.....	.....	.....	.....	.....	.....	297,190
1915	.....	.....	.....	.....	.....	.....	.....	.....	254,008
1916	.....	.....	79,234	.....	568	.....	.....	.....	540,701
1917	.....	.....	49,162	.....	490	.....	.....	.....	.....
1918....	.....	.....	32,101	.....	852	.....	.....	.....	.....

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Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1903	109,594	13,241	89,229	1,808	9,873	67,258	39,305
1904	148,547	11,212	72,921	1,344	9,352	88,083	35,737
1905	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907	106,050	.....	.....	961	7,693	114,699	33,503
1908(k)	195,000	.....	.....	1,000	8,482	137,900	40,312
1909(k)	196,300	.....	.....	1,900	9,683	120,600	32,749
1910	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913	8,250	.....	100,882	2,542	.....	178,719	.....
1914	116,018	.....	231,265	.....	7,216	.....	30,361
1915	102,757	.....	43,144	.....	8,914	.....	36,825
1916	128,095	.....	16,172	445	10,548	56,727	63,206
1917	.....	.....	.....	333	.....	36,430	72,909
1918	.....	.....	.....	50	.....	61,356	45,587

MINERAL AND METALLURGICAL EXPORTS OF FRANCE (a) (k)

(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic.	Cement.	Coal and Coke.	Copper.		Gold. Kg.(d)
		Ore.	Metal.				Ore. (c)	Metal	
1901	307	645	741	.....	242,010	908,583	16,066	14,776	1,869
1902	748	595	666	.....	210,590	910,760	20,489	14,423	1,517
1903	666	904	1,358	.....	233,835	2,238,735	12,487	11,403	3,139
1904	664	1,191	720	.....	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	.....	275,503	(i)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	.....	329,879	(i)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	.....	366,624	(i)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(i)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(i)1,493,308	6,200	18,775	5,366
1910	4,148	4,583	2,163	2,411	315,020	(i)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(i)1,635,000	8,335	22,690	.....
1912	6,605	1,673	2,890	1,497	361,425	(i)2,320,349	6,374	42,307	775
1913	.....	608	.....	1,850	.....	.....	10,154	.....	.....
1914	.....	.....	.....	.....	.....	913,432	.....	.....	.....
1915	.....	.....	.....	.....	.....	239,905	.....	.....	.....
1916	.....	.....	.....	.....	.....	226,917	.....	.....	.....

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1901	258,925	96,463	25,220	56,347	3,490	718	5,289
1902	422,677	213,081	23,828	121,932	2,414	648	1,948
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1,860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1910	4,892,542	110,086	122,543	(k)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	170,000	12,276	1,660	2,282
1913	.....	.....	.....	.....	14,263	.....	1,705
1914	4,828,592	.....	.....	.....	.....	.....	.....
1915	94,864	(l)152,116	.....	.....	.....	.....	.....
1916	74,561	(l)163,642	.....	.....	.....	.....	.....

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Year.	Nickel, Refined.	Phosphate Rock.	Plaster.	Pyrite.	Silver, *Kg.* (*e*)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1902.....	397	62,375	110,270	63,920	17,184	654	47,724	16,158
1903.....	720	72,252	131,245	119,173	43,690	1,994	62,731	12,657
1904.....	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905.....	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906.....	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907.....	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908.....	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909.....	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910.....	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911.....	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912.....	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913.....	.....	21,128	.....	.....	.....	.....	58,203	.....
1914.....	.....	11,219	.....	.....	.....	.....	.....	.....
1915.....	.....	1,796	.....	.....	.....	.....	.....	.....
1916.....	.....	1,437	.....	.....	.....	.....	.....	.....

(*a*) From *L'Economiste Francais* (representing the *Commerce Spécial*), except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry, and crude platinum. (*e*) Silver in sheets, leaves, wire, and jewelry. (*f*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke (*k*) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911 and 1914–1918, from *l'Echo des Mines et Metallurgie*. (*l*) Includes bars and steel.

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GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY (*a*)

Year.	Alum.	Aluminium Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. *Kg.*	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1900	4,355	44,372	4,379	2,415	89,685	232	13,553	109,290,237	40,498,019
1901	4,145	46,807	4,035	2,549	90,193	184	13,144	108,539,444	44,479,970
1902	4,108	47,905	3,959	2,828	88,374	196	12,625	107,473,933	43,126,281
1903	3,934	49,727	4,369	2,768	87,454	159	16,565	116,637,755	45,819,488
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	.....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	.....	.....	4,869	.....	96,117	224	43,000	174,875,297	80,934,797
1913	.....	.....	.....	.....	.....	.....	.....	**191,511,000**	**87,475,000**

Year.	Cobalt, Nickel, and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (*b*)	Ingots.	Sulphate.		
1899	1,270	733,619	95	34,634	5,142	$1,731,153	5,196
1900	4,495	747,749	4,207	30,929	5,076	2,030,200	9,248
1901	10,479	777,339	365	31,317	5,192	1,830,835	4,435
1902	12,433	761,921	447	30,578	4,997	1,770,361	5,023
1903	14,607	772,695	583	31,214	5,200	1,709,223	3,720
1904	14,016	798,214	641	30,264	6,584	1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	.....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	.....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	**3,322,700**	12,532

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (*c*)	Wrought Iron and Steel.	Sulphate. (*d*)	Ore.	Pig.	Litharge.
1899	17,989,635	8,153,133	7,532,524	10,931	144,370	129,225	3,562
1900	18,964,294	8,520,540	7,377,275	10,913	148,257	121,513	3,088
1901	16,570,182	7,880,087	7,033,438	11,148	153,341	123,098	4,101
1902	17,963,591	8,529,900	8,317,231	.....	167,855	140,331	4,197
1903	21,230,650	10,017,901	9,226,898	12,243	165,991	145,319	4,428
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,687
1912	27,199,944	15,220,881	16,508,987	.....	142,839	192,618	4,135

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Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (f)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1899 ...	21,370	39,540	61,329	27,027	207,506	1,108,159	26,103	9,765	1,384,972
1900 ...	19,397	48,591	59,204	50,375	271,512	1,227,873	30,853	15,368	1,822,758
1901 ...	21,018	46,714	56,691	44,095	294,666	1,498,569	37,394	15,612	2,036,325
1902 ...	19,658	39,262	49,812	49,725	267,512	1,322,623	28,278	18,147	1,962,384
1903 ...	22,990	37,844	47,994	62,680	280,248	1,557,243	36,674	23,631	2,073,720
1904 ...	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905 ...	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906 ...	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907 ...	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908 ...	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909 ...	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910 ...	32,207	57,314	80,560	145,168	741,259	4,249,667	84,583	37,438	4,062,004
1911 ...	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912 ...	85,387	99,442	185	134,986	506,744	5,889,238	123,407	54,435	.....

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1899....	144,623	861,123	571,058	13,506	467,590	79,062	1,663	813,141
1900....	169,447	926,563	587,464	12,593	415,735	90,468	1,445	829,376
1901....	157,433	985,050	578,751	11,577	403,796	76,066	963	835,000
1902....	165,225	1,010,412	572,846	11,724	430,610	90,742	.....	894,409
1903....	170,867	1,095,541	598,394	11,467	396,253	83,087	219	928,190
1904....	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905....	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906....	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907....	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908....	219,456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909....	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910....	215,708	1,424,064	669,120	6,646	420,003	84,787	1,272	1,616,336
1911....	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,455
1912....	242,121	1,352,524	671,622	595	.....	.....	.....	1,649,681

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1900	80	2,031	(g) 143	43	639,215	155,790	6,027
1901	82	1,464	(g) 135	43	647,496	166,283	5,552
1902	104	2,779	.....	31	702,504	174,927	.....
1903	110	3,065	1,064	35	682,853	182,548	5,994
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	.....	6,597	987	.....	704,590	205,691	6,092
1907	.....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,308
1911	.....	12,412	3,749	.....	699,970	235,776	6,703
1912	(i)	10,646	3,094	70	643,598	269,161	6,413
1913	.....	.....	.....	.....	637,308	283,190	.....

(a) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported, 1 mark = $0.238. (b) Includes black copper. (c) Includes ferro manganese and spiegeleisen. (d) Contains a small quantity of copper and iron sulphate mixed. (f) Compound of potassium chloride and magnesium sulphate. (g) Includes nickel sulphate. (i) Included with cobalt, nickel and bismuth.

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MINERAL PRODUCTION OF BADEN (a)
(In metric tons or dollars; 4 marks = $1)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufactures of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(c) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(c) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(b)	42,408	107,784	11,909	244
1912....	.....	15,871	.....	51,778	.....	.....	.....
1913....	.....	16,445	.....	49,767	.....	.....	.....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899.....	(b)	31,197	13,660	12	357
1900.....	67	32,699	15,938	9	3,004
1901.....	369	32,835	17,081	8	2,870
1902.....	450	32,192	19,265	11	2,958
1903.....	350	32,383	19,755	11	3,171
1904.....	265	32,148	35,517	12	5,063
1905.....	264	31,393	40,781	12	4,046
1906.....	246	31,288	38,655	15	1,466
1907.....	278	32,078	42,831	25	2,198
1908.....	329	33,993	41,455	13	2,793
1909.....	372	34,040	42,219	14	3,253
1910.....	419	32,729	56,069	7	3,345
1911.....	191	32,118	47,796	14	3,067
1912.....	428	32,326	.....	14	3,730
1913.....	480	33,502	.....	13	3,882

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badischen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA (a)
(In metric tons; 4 marks = $1)

Year.	Barytes.	Kaolin.	Coal.	Coal (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluor-spar.	Graphite.
1899..	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900..	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901..	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902..	8,034	92,073	1,233,588	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,397	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	.....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	.....	260	6,666	4,220	12,532
1913..	.....	.....	811,000	1,895,000	.....	.....	.....	.....	.....

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Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1899....	29,727	181,981	61,415	(b)	92,459	83,821	134,007	11,962
1900....	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901....	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	.....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904....	22,766	180,342	37,780	40	106,025	92,200	125,483	13,836
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906....	50,763	203,596	38,508	.....	122,115	97,812	150,129	.....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,590
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	.....	339,401	8,175
1912....	57,114	450,074	(c)	.....	396,656	195,606	998,624	9,903

Year.	Marl. (For Cement)	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1899....	220,716	9,287	2,516	802	2,197	1,570	123,273
1900....	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901....	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902....	178,301	13,947	2,635	832	.....	.....	.....
1903....	200,407	19,486	2,324	879	1,866	.....	.....
1904....	170,698	19,107	3,427	1,139	1,709	.....	.....
1905....	231,310	18,285	3,301	911	1,872	.....	.....
1906....	230,271	22,304	3,918	1,053	.....	.....	.....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,083	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	3,221	.....	254,708

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) With cast iron.

MINERAL PRODUCTION OF PRUSSIA (a)

(Metric tons; 4 marks = $1)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1900....	103	3,025	1,585	3,531	23,891	217	13,533	101,966,158
1901....	611	2,404	1,446	3,050	26,450	164	13,144	101,203,807
1902....	219	3,542	1,514	2,909	28,035	172	12,625	100,115,315
1903....	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,755,621
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,080
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,058	143,771,612
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,080
1912....	104	.....	.....	4,870	21,241	186	.....	165,302,784
1913....	180	.....	.....	5,008	17,795	160	.....	179,861,015

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Year.	Coal (Lignite).	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1900....	34,007,542	4	52	27,156	113	747,601	4,207
1901....	37,491,412	36	66	28,422	78	765,241	281
1902....	36,228,285	76	74	27,893	119	751,496	346
1903....	38,462,766	65	87	28,386	110	761,188	488
1904....	41,153,576	41	85	27,450	95	782,049	601
1905....	44,148,751	22	99	28,874	102	769,381	1,052
1906....	47,912,721	7	98	29,166	94	755,812	525
1907....	52,660,597	*Nil.*	109	28,945	64	755,203	499
1908....	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
1910....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
1911....	60,531,943	*Nil.*	107	30,986	27	919,827	996
1912....	65,803,959	*Nil.*	.....	.....	.....	967,785	.....
1913....	70,051,871	*Nil.*	.....	.....	.....	941,402	.....

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1900.....	1,660	1,511	1,076.6	5,781,892	4,268,069	10,225	112,738
1901.....	1,951	1,952	1,087.1	5,315,628	3,831,670	10,239	113,939
1902.....	1,937	761	1,138.0	5,633,089	3,362,887	11,214	127,283
1903.....	2,254	421	949.5	6,614,788	3,786,743	11,086	133,405
1904.....	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905.....	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906.....	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907.....	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
1908.....	3,116	398	786.6	7,989,280	4,311,593	14,062	153,541
1909.....	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
1910.....	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
1911....	2,464	114	520.	10,477,263	4,948,711	15,468	147,538
1912.....	.....	.....	.....	.....	5,331,240	.....	.....
1913.....	.....	.....	.....	.....	5,461,670	.....	.....

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1900.....	133,483	2,366	58,016	1,376	3,896	115	2,850
1901.....	139,285	2,885	55,866	1,660	9,922	120	2,800
1902.....	152,282	2,516	48,882	1,605	11,816	159	2,780
1903.....	151,746	2,710	47,110	1,945	14,058	173	2,850
1904.....	150,328	2,517	52,092	2,333	13,518	207	3,200
1905.....	138,928	2,272	51,048	2,631	10,432	220	3,170
1906.....	127,322	2,744	51,881	2,648	7,472	187	3,635
1907.....	133,528	2,959	72,442	2,093	7,557	189	3,707
1908.....	141,316	4,190	67,241	2,622	8,238	181	3,183
1909.....	158,811	2,365	76,741	3,186	10,095	163	3,435
1910.....	146,830	3,076	80,325	3,497	10,053	213	142
1911.....	135,366	3,441	86,902	3,744	9,609	244	.....
1912.....	140,158	.....	92,474	.....	12,091	.....	.....
1913.....	143,799	.....	(*b*)	.....	13,538	.....	.....

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Year.	Petroleum.	Potassium Salts.		Pyrite.	Quicksilver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1900.....	27,731	857,271	1,264,993	159,186	1,711	287,005	354,603
1901.....	24,098	1,068,237	1,131,703	148,457	1,713	290,869	353,557
1902.....	29,520	943,450	1,344,541	155,410	1,828	291,296	359,006
1903.....	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904.....	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905.....	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906.....	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.....	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908.....	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909.....	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910.....	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911.....	98,611	3,502,762	2,920,725	203,249	2,861	337,583	527,034
1912.....	87,443	4,256,476	3,287,177	233,397	.....	343,883	527,275
1913.....	71,178	4,426,054	3,658,109	228,405	.....	353,260	526,218

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1900.....	266,577	1	1,207	593,109	2,010	636,068	155,760	3,742
1901.....	246,286	6	772	609,041	1,443	644,504	166,223	3,369
1902.....	273,901	17	250	677,798	2,753	699,392	174,892	3,381
1903.....	255,722	13	16	724,784	3,042	679,320	182,472	3,586
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	.....	.....	.....	.....	.....	647,081	.....	.....
1913.....	.....	.....	.....	.....	.....	649,695	.....	.....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*
(*b*) Included in "Iron Ore."

MINERAL IMPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (*b*)
1901 ...	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,764
1902 ...	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,926
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,666
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	.....	2,598	19,466

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Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (d), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite, Cannel.	Lignitic.	
1901 ...	2,537	24,113	9,526	87,262	(d)29,611	18,222	6,297,389	8,108,943	400,197
1902 ...	2,057	26,698	11,287	52,018	(d)26,408	10,152	6,425,658	7,882,010	382,488
1903 ...	2,567	22,316	14,081	49,870	(d)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(d)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(d)35,529	11,998	9,399,693	7,945,261	713,619
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,956	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1901 ...	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902 ...	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904 ...	9,071	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(k)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(k)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(k)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(k)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	3,952	4,336	(k)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	4,145	3,323	(k)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	7,074	5,925	(k)
1913 ...	11,796	147,416	13,658	27,594	225,392	.....	3,869	2,954	(k)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1901 ...	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902 ...	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,973	303	10,812,595	129,850	143,598	100,515	3,938
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980

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Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1901....	8,897	204,420	9,403	1,947	1,981	985,904	118,999	313
1902....	12,237	222,010	7,719	1,458	1,585	1,006,829	125,667	350
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,887	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15,703	2,598	1,591	955,482	260,242	200
1912....	69,064	420,709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209

Year.	Phosphate Rock.	Potassium Salts.							Pumice Stone. (g)	Pyrite.
		Chloride.	Cyanide. (f)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1901....	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902....	430,043	261	3	10	1,889	2,112	42	266	2,070	482,095
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,526
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,218
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	792,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,023,952

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (n)
				Soda, Calcined.	Nitrate (Chile Saltpeter).	Sulphate and Sulphite.	
1901	651	23,901	733,931	178	529,568	7,921	19,739
1902	648	26,404	831,282	121	467,024	7,308	34,035
1903	674	20,118	877,394	114	467,130	6,058	24,183
1904	691	18,743	846,738	179	506,172	9,598	18,055
1905	729	20,726	888,665	143	540,916	4,752	13,720
1906	698	16,997	813,388	189	593,218	7,405	5,212
1907	831	23,109	568,046	257	591,131	10,446	5,595
1908.	648	24,975	562,853	293	604,457	4,404	4,211
1909	723	19,319	492,771	181	665,450	9,214	4,277
1910	836	30,443	766,320	105	749,945	9,302	4,852
1911	919	29,067	685,943	559	730,939	5,976	3,251
1912	990	17,887	1,248,693	1,987	812,898	5,609	4,359
1913	961	21,422	.....	2,633	774,298	10,074	3,965

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Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc White, Zinc Gray, Lithophone.
1901....	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902....	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,189
1908....	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108

MINERAL EXPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Aluminium Wares, etc.	Aluminium Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1901....	282	2,270	31,171	3,196	9,842	283	76	826
1902....	410	2,608	34,005	3,351	5,744	410	105	954
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,208
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461

Year.	Arsenic.		Asbestos.	Barytes. (*b*)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1901 ...	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902 ...	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903 ...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904 ...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905 ...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906 ...	.....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907 ...	(*m*)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908 ...	(*m*)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909 ...	(*m*)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910 ...	(*m*)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911 ...	71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912 ...	73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913 ...	.....	2,612	1,461	158,065	5,649	7,647	355	3,433	239

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Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1901....	2,096,931	11,588	529,785	96	26,678	7,700	5,097	1,942
1902..	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903....	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904....	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905....	2,761,030	16,009	936,694	107	28,908	10,006	5,958	2,180
1906....	3,415,347	15,680	1,095,029	(i)	6,414	10,728	7,241	3,018
1907....	3,792,580	25,746	1,260,135	(i)	20,950	13,411	6,113	2,016
1908....	3,577,496	26,817	1,493,054	(i)	21,729	17,209	6,868	2,994
1909....	3,444,791	23,579	1,620,480	(i)	22,437	15,395	6,495	1,290
1910....	4,125,898	20,360	1,988,177	(i)	23,751	19,351	7,654	2,108
1911....	4,555,477	35,855	2,477,492	(i)	27,396	19,669	7,106	3,346
1912....	5,850,350	60,557	2,746,536	(i)	21,514	20,245	7,854	3,812
1913....	6,411,418	86,920	3,163,742	(i)	25,221	.....	7,208	4,013

Year.	Bromine Salts.	Calcium.		Cement.	Chalk, Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous, Anthracite and Cannel.	Lignitic
1901 ...	249	275	888	560,612	(d)14,134	581	1,299	15,269,267	21,718
1902 ...	357	126	1,346	699,378	(d) 8,475	846	1,758	16,101,141	21,766
1903 ...	435	335	1,831	742,381	(d)12,211	37	1,921	17,389,934	22,499
1904 ...	411	608	2,381	635,248	(d)11,359	47	2,432	17,996,726	22,135
1905 ...	634	709	2,831	675,664	(d)13,081	43	2,507	18,156,998	20,118
1906 ...	643	545	(l)	736,579	4,287	(h) 36	2,942	19,550,964	18,759
1907 ...	655	918	(l)	692,982	2,919	(h) 149	3,110	20,056,503	22,065
1908 ...	506	844	(l)	528,847	2,108	(h) 110	3,215	21,190,777	27,877
1909 ...	486	968	(l)	611,893	4,395	(h)5,023	3,023	23,350,705	39,815
1910 ...	323	1,482	(l)	725,356	3,359	(h) 386	3,998	24,257,651	62,441
1911 ...	.....	2,120	(l)	845,850	1,537	(h)1,795	2,815	27,412,218	58,071
1912 ...	372	971	(l)	1,056,622	2,890	(h) 778	3,221	31,145,057	56,966
1913 ...	405	.....	(l)	1,129,563	3,409	(h) 681	3,313	34,573,514	60,345

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1901.....	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902.....	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903.....	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904.....	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905.....	4,495	286	15,019	1,971	52,886	27	3,698,563	380,824
1906.....	4,712	(k)	15,493	2,013	63,516	46	3,851,791	479,772
1907.....	6,212	(k)	16,624	2,176	70,737	44	3,904,400	275,170
1908.....	4,393	(k)	14,925	2,469	60,992	51	3,067,737	257,849
1909.....	2,232	(k)	14,534	2,377	63,220	59	2,825,007	471,045
1910.....	2,929	(k)	17,988	3,424	89,590	70	2,952,634	786,854
1911.....	4,151	(k)	23,073	3,822	102,754	73	2,581,698	829,393
1912.....	3,386	(k)	21,145	4,501	108,624	79	2,309,628	1,016,261
1913.....	5,382	(k)	25,523	5,423	132,693	92	2,613,158	782,911

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Year.	Lead.					Lime, Chloride of.	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1901 ...	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902 ...	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,058	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,436	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388

Year.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products. (f)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1901.....	12,671	390	1,700	655	963	149	2,260
1902.....	14,392	689	1,856	824	1,177	260	1,103
1903.....	15,161	700	2,027	701	1,975	286	4,342
1904.....	16,395	1,203	2,447	760	1,763	236	3,222
1905.....	17,603	1,034	2,757	7,286	1,746	228	3,720
1906.....	4,290	954	509	673	9,982	228	5,484
1907.....	4,097	930	692	770	10,552	165	1,494
1908.....	15,675	1,349	921	1,008	10,852	160	1,196
1909.....	18,130	1,606	1,300	588	11,621	168	5,429
1910.....	19,355	1,381	1,642	472	17,141	160	5,044
1911.....	22,426	1,592	1,295	274	18,905	192	10,591
1912.....	27,313	1,677	1,167	244	19,635	219	7,032
1913.....	30,348	1,673	1,999	.....	.....	192	6,885

Year.	Potassium Salts.						Potassium and Potassium-magnesium Sulphate.	Pumice Stone. (g)	Pyrite.
	Carbonate	Cyanide. (f)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1901 ...	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902 ...	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,715	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214

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Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicarbonate.	Carbonate.	Hydroxide.	Nitrate. (Chile Saltpeter).	Soda, Calcined.	Sulphate and Sulphite.
1901...	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902...	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,314	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,598	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	.....	1,869	1,354	13,030	27,507	69,993	83,239

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (n)	Salts.		
1901	2,791	2,763	592,347	384	1,022	621	42,853
1902	2,656	4,565	499,220	762	1,546	576	47,666
1903	2,977	5,845	501,385	819	1,389	1,052	50,109
1904	2,272	5,489	631,762	613	1,207	1,418	52,696
1905	2,133	6,569	852,454	613	1,386	1,198	48,701
1906	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911	5,193	7,837	1,154,974	595	.....	1,757	64,888
1912	5,167	7,640	.....	1,830	138	1,746	75,962
1913.....	5,667	9,226	.....	1,958	330	3,472	64,968

Year.	Superphosphate.	Tin, Crude.	Zinc.				Zinc White, Zinc Gray and Lithophone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1900.....	77,118	1,626	34,941	51,899	16,709	382	20,729
1901.....	79,190	1,683	14,002	54,490	16,517	324	24,201
1902.....	77,818	2,271	46,965	70,292	17,015	430	28,400
1903.....	99,672	2,581	40,458	67,057	15,715	264	27,527
1904.....	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.....	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.....	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.....	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.....	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.....	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.....	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.....	221,521	7,582	48,998	81,042	36,093	387	34,419
1912.....	271,349	6,368	51,242	105,328	26,379	.....	44,169
1913.....	282,653	6,437	44,731	109,606	24,965	.....	46,106

(*a*) From *Statistisches Jahrbuch für das Deutsches Reich*. (*b*) Includes celestite. (*d*) Includes precipitated chalk. (*f*) Includes sodium cyanide. (*g*) Includes tripoli. (*h*) Includes nickel ore. (*i*) Included under chromium ore. (*k*) Included under bauxite. (*l*) Included under magnesium chloride. (*m*) Includes all alkali metals. (*n*) Includes witherite.

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GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE (*a*)
(In metric tons or dollars; 1 drachma = 20 cents)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore, Manganiferous.	Lead, Soft.	Lead Ore, Argentiferous.	Lead, Argentiferous.	Lead, Fume.	Lignite.
1903..	8,478	5,586	94	531,804	152,740	(*b*)	(*b*)	12,361	(*b*)	8,687
1904..	6,530	6,182	117	422,159	108,319	(*b*)	(*b*)	15,186	(*b*)	13,500
1905..	8,900	6,972	57	465,622	89,687	(*b*)	(*b*)	13,729	(*b*)	11,757
1906..	11,530	7,718	85	680,620	96,382	(*b*)	(*b*)	12,308	(*b*)	11,582
1907..	11,730	10,652	105	768,863	92,970	(*b*)	(*b*)	13,814	(*b*)	11,719
1908..	4,350	7,471	61	531,368	65,757	(*b*)	(*b*)	15,892	(*b*)	8,786
1909..	9,600	8,193	208	475,616	54,926	(*b*)	(*c*)	14,948	(*b*)	3,873
1910..	9,450	12,939	243	535,482	50,015	(*c*)	8,355	16,710	(*b*)	1,500
1911..	12,915	10,544	1,263	496,731	27,482	.....	182,324	14,283	.....	.....
1912..	6,468	3,359	127	376,931	12,212	.....	175,463	14,489	.....	.....
1913..	6,342	5,560	2,230	310,078	6,323	.....	159,348	18,309	.....	170
1914..	7,059	16,112	639	299,286	1,315	.....	151,581	20,684	.....	20,002
1915..	10,420	14,338	1,648	157,340	1,041	.....	104,905	11,595	.....	39,745
1916..	9,880	19,871	356	84,985	818	.....	95,418	9,424	.....	116,946

Year.	Magnesite.			Manganese Ore.	Pozzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1903...	28,415	(*b*)	(*b*)	9,340	40,978	26,000	1,266	(*b*)	12,350
1904...	9,133	(*b*)	(*b*)	8,549	44,644	27,000	1,225	(*b*)	19,913
1905...	37,063	(*b*)	(*b*)	8,171	41,900	25,201	1,126	(*b*)	22,562
1906...	40,584	(*b*)	(*b*)	10,040	30,622	25,167	(*b*)	(*b*)	26,258
1907...	55,816	(*b*)	(*b*)	11,139	39,637	26,966	(*b*)	(*b*)	30,346
1908...	63,079	(*b*)	(*b*)	10,750	52,312	23,988	(*b*)	28,739	24,101
1909...	56,797	294	16,609	5,374	46,238	29,448	(*b*)	41,656	30,159
1910...	18,073	295	19,982	41	31,609	25,978	(*b*)	(*f*)5,845	28,898
1911...	86,956	275	27,530	(*e*) 733	31,647	26,952	(*h*)31,905	35,856	30,512
1912...	106,338	496	33,848	(*e*)8,082	19,400	31,400	(*h*)31,938	39,585	28,912
1913...	98,517	.....	31,815	(*e*) 556	24,906	19,215	(*h*)128,932	30,717	20,646
1914...	136,701	493	28,563	558	28,909	29,717	(*h*)129,129	32,440	22,308
1915...	159,981	161	27,248	408	13,471	16,856	(*h*) 12,121	33,121	20,209
1916...	199,484	*Nil*	29,933	3,600	8,564	34,522	(*h*) 19,938	25,853	12,612

(*a*) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (*b*) Not reported. (*c*) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (*e*) Sales. (*f*) Production in 1910 was 37,108 tons. (*h*) Including pyrite.

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INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA (*a*)
(In metric tons or dollars; £1 = $5)

Year.	Amber.	Bauxite.	Coal.	Chromite.	Copper Ore.	Corundum.	Diamonds, *Carats.*	Gold. (*c*)	Graphite.	Gypsum.	Iron Ore.	Jade. (*e*) *Cwt.*	Lead Ore.	Magnesite.
1904	$4,190	.....	8,348,561	3,654	.....	.....	286.5	$11,513,340	2,955	.....	72,832	130	.....	1,193
1905	4,725	.....	8,552,422	2,751	.....	.....	172.4	11,760,957	2,361	.....	104,984	106	.....	2,645
1906	3,545	.....	9,940,247	4,445	.....	.....	305.9	10,852,546	2,642	.....	92,933	116	.....	1,861
1907	1,925	.....	11,325,696	18,596	.....	.....	628.0	10,348,795	2,472	.....	69,829	2,636	.....	189
1908	1,820	.....	12,974,558	4,821	.....	.....	140.8	10,597,404	2,919	.....	73,457	3,211	.....	7,655
1909	1,435	32	12,060,550	9,398	7	41	147.3	10,728,900	3,182	17,579	84,774	2,487	12,534	749
1910	1,415	67	12,249,744	1,765	1,174	249	77.7	10,717,300	4,319	13,751	55,461	1,908	30,999	5,265
1911	665	12	12,919,587	3,865	2,273	312	53.0	10,890,804	4,047	11,109	372,049	2,063	35,738	3,546
1912	895	962	14,942,340	2,936	9,774	392	27.8	11,054,608	*Nil*	21,372	589,508	806	25,924	15,626
1913	145	1,202	16,467,337	5,767	3,871	405	115.7	11,152,408	*Nil*	25,363	376,779	3,281	20,626	16,457
1914	1,370	522	16,729,338	5,982	5,410	63	54.7	11,378,435	*Nil*	22,626	448,741	3,765	34,227	1,707
1915	995	890	17,379,305	3,828	9,028	120	36.0	11,531,671	71	22,926	396,554	3,693	42,964	7,570
1916	.....	762	17,532,103	20,484	2,714	1,898	3.6	11,206,510	1,341	16,286	418,387	3,783	14,197	17,924
1917	3,420	1,385	18,506,143	27,497	20,432	2,104	18.2	10,811,712	105	16,952	419,927	3,961	72,787	18,495

Year.	Manganese Ore.	Mica.	Monazite.	Petroleum, *Gallons.*	Rubies, *Carats.*	Salt.	Saltpeter (Potassium Nitrate.)	Sapphires, *Carats.*	Silver, *Oz.*	Talc.	Tin and Tin Ore.	Tungsten Ore.
1904	152,601	1,126	.....	118,491,382	265,901	1,122,731	14,200	(*f*)	.....	.....	71	.....
1905	250,788	1,302	.....	144,798,444	266,584	1,212,504	15,745	(*f*)	.....	.....	77	.....
1906	579,231	2,669	.....	140,553,122	329,692	1,176,269	16,822	(*f*)	.....	.....	97	.....
1907	916,770	2,652	.....	152,045,677	604,217	1,120,427	18,664	(*f*)	.....	.....	80	.....
1908	685,135	2,720	.....	176,646,320	356,044	1,300,416	19,620	(*f*)	.....	.....	96	.....
1909	654,974	1,671	.....	233,678,087	265,010	1,274,682	20,953	(*f*)	27,500	593	85	7
1910	813,721	1,153	.....	214,928,647	262,019	1,577,823	16,140	(*f*)	49,680	250	167	402
1911	681,015	1,722	.....	225,792,094	288,213	1,347,116	14,679	(*f*)	103,580	934	189	1,329
1912	643,209	2,227	.....	249,083,518	323,245	1,477,971	14,797	(*f*)	93,476	800	382	1,697
1913	828,088	2,324	1,253	277,555,225	203,925	1,496,760	14,461	21,353	125,209	2,564	359	1,713
1914	693,824	2,057	1,205	259,342,710	193,333	1,529,002	15,738	56,709	236,446	1,015	374	2,363
1915	457,668	1,379	1,126	287,093,576	167,904	1,956,311	18,389	39,718	285,387	1,094	568	2,687
1916	655,592	2,205	1,313	297,189,787	136,783	1,512,616	25,459	34,100	759,012	1,236	589	4,057
1917	600,325	2,078	1,972	282,759,523	132,409	1,450,638	21,627	32,369	1,581,838	7,955	820	4,615

(*a*) Records of the Geological Survey of India. (*b*) Not reported. (*c*) £1 = $4.866. (*d*) Production of iron ore in Bengal only. (*e*) Exports in cwt. o f 112 lb. (*f*) Included in rubies.

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ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY (*a*)
(In metric tons or dollars; 5 lire = $1)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic, and Bitumen.	Asphaltic Rock.	Barytes.
1903.....	3,980	2,210	8,100	905	6,927	35,757	89,078	12,420
1904.....	2,490	2,210	8,000	836	5,712	30,817	111,390	12,290
1905.....	2,975	2,740	8,500	327	5,083	26,838	106,586	12,670
1906.....	2,878	2,800	7,500	537	5,704	34,386	130,225	12,020
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	15,732
1908.....	2,875	2,100	6,165	345	2,821	34,761	134,163	15,432
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	16,240
1910.....	2,510	2,773	6,081	*Nil*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil*	2,441	50,179	188,133	13,620
1912.....	1,299	2,727	6,002	*Nil*	1,878	52,707	181,397	13,420
1913.....	1,009	3,308	5,976	76	1,822	56,750	171,097	12,970
1914.....	1,307	3,229	3,700	138	555	33,752	119,853	12,970
1915.....	1,329	2,094	4,850	548	4,334	25,701	47,650	17,850
1916.....	(*b*)	(*b*)	3,370	660	6,509	16,662	16,829	21,650
1917	(*b*)	(*b*)	4,855	486	5,789	13,608	8,645	19,000

Year.	Borax, Refined.	Boric Acid.		Coal. (*c*)	Coal (Briquettes).	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1903...	377	2,583	187	346,887	724,993	554,559	114,823	11,217	18,164
1904...	569	2,624	314	362,151	903,610	607,297	157,503	11,873	17,237
1905...	1,007	2,700	749	412,916	842,250	627,984	149,035	16,132	26,212
1906...	1,062	2,561	562	473,293	829,277	672,689	147,137	15,456	34,270
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	363,493	68,136	22,908	44,626
1912...	813	2,309	760	663,812	876,565	437,706	86,001	26,659	52,311
1913...	1,070	2,410	743	701,079	896,091	1,336,382	99,487	24,625	44,497
1914...	1,164	2,537	838	781,288	968,600	1,276,318	88,953	1,839	31,302
1915...	829	2,497	1,277	953,082	721,409	1,365,109	74,470	1,840	41,272
1916...	(*b*)	2,293	1,114	1,305,840	(*b*)	(*f*) 515,561	88,475	1,867	(*b*)
1917...	(*b*)	2,335	(*b*)	1,722,157	(*b*)	(*f*) 447,387	86,842	1,248	(*b*)

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1903.....	5,734	$24,667	7,920	374,790	90,744	177,392	11,275	154,134
1904.....	6,746	36,996	9,765	409,460	112,598	181,385	16,655	177,086
1905.....	1,200	7,200	10,572	366,616	181,248	205,915	18,560	244,793
1906.....	6,543	42,720	10,805	384,217	180,940	236,946	16,350	332,924
1907.....	13,475	41,000	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	48,223	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	18,230	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	11,746	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	16,440	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	13,271	13,170	582,066	379,989	179,516	28,916	801,907
1913.....	2,047	23,580	11,145	603,116	426,755	591,763	29,185	846,085
1914.....	205	(*b*)	8,567	706,246	385,340	705,273	26,284	796,152
1915.....	296	1,420	6,176	679,970	377,510	(*b*)	29,094	1,009,240
1916.....	*Nil*	(*b*)	8,182	942,244	467,005	(*b*)	(*b*)	1,269,486
1917.....	*Nil*	(*b*)	12,117	993,825	471,188	(*b*)	(*b*)	1,331,641

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Year.	Lead.		Magnesite.	Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum, Benzene, etc.
	Ore.	Pig.						
1903.....	42,443	22,126	.....	1,930	4,735	374,975	2,485	4,577
1904.....	42,846	23,475	.....	2,836	2,836	390,118	3,543	6,388
1905.....	39,03	10,77	.....	5,384	5,384	389,869	6,122	9,924
1906.....	40,945	21,268	.....	3,060	20,500	430,202	7,452	10,954
1907.....	(*d*)43,037	22,978	.....	3,654	18,874	434,512	8,326	10,556
1908.....	36,649	26,003	.....	2,750	17,812	425,690	7,088	10,876
1909.....	37,945	22,133	.....	4,700	25,830	391,295	5,895	11,077
1910.....	36,840	14,495	.....	4,200	25,700	427,274	7,069	12,149
1911.....	39,008	16,684	.....	3,515	6,482	497,741	10,390	15,569
1912.....	41,680	21,450	.....	2,641	*Nil*	522,088	7,479	13,792
1913.....	44,654	21,674	600	1,622	*Nil*	509,342	6,572	11,160
1914.....	45,538	20,464	1,140	1,649	*Nil*	431,087	5,542	11,873
1915.....	41,590	21,812	9,200	12,577	*Nil*	246,883	6,105	14,332
1916.....	39,460	24,362	18,252	18,147	4,360	200,700	7,035	20,467
1917.....	39,096	16,237	31,070	24,532	4,806	134,233	5,668	125,101

Year.	Pumice Stone.	Pyrite (Cupriferous in Part).	Quicksilver.		Salt.			Silver, Bullion. *Kg.*
			Ore.	Metal.	Brine.	Rock.	Sea.	
1903.....	8,300	101,455	55,528	312	10,962	25,911	451,633	24,388
1904.....	11,600	112,004	60,403	352	11,878	18,638	433,810	24,943
1905.....	11,300	117,667	63,378	369	12,756	19,669	405,274	20,215
1906.....	16,366	122,364	80,638	417	13,751	19,007	496,872	20,362
1907.....	11,500	126,925	76,561	434	19,238	31,540	454,454	20,502
1908.....	15,000	131,721	82,534	684	15,180	24,033	473,857	20,746
1909.....	10,000	149,084	97,592	771	15,081	28,026	421,362	20,534
1910.....	12,900	165,688	87,129	894	16,600	39,197	447,440	14,237
1911.....	16,430	165,273	97,803	955	17,251	43,763	460,439	12,143
1912.....	17,386	277,585	88,200	1,000	18,775	39,954	466,220	14,363
1913.....	14,793	317,334	109,379	1,004	17,727	41,323	750,518	13,094
1914.....	14,376	335,531	119,223	1,073	18,396	41,715	762,040	15,254
1915.....	10,242	369,320	110,642	985	17,914	33,267	627,050	15,362
1916.....	9,287	410,290	132,524	1,093	16,913	50,294	330,013	15,131
1917.....	11,312	500,782	(*b*)	1,071	12,733	43,042	322,666	10,679

Year.	Sulphur.			Talc, Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1903.....	553,751	139,376	139,464	6,300	157,521	126
1904.....	527,563	189,266	163,695	6,740	148,365	189
1905.....	568,927	180,676	180,774	6,626	147,834	5
1906.....	499,814	176,476	170,990	7,894	155,751	69
1907.....	426,972	151,338	160,617	8,850	160,517	188
1908.....	445,312	160,693	156,995	9,410	(*e*)152,254	(*b*)
1909.....	435,060	132,531	144,579	9,530	(*g*)130,890	(*b*)
1910.....	(*i*)430,366	171,570	169,093	11,580	(*g*)146,307	(*b*)
1911.....	414,161	158,977	166,802	14,156	139,719	(*b*)
1912.....	389,451	164,864	168,514	14,324	149,776	(*b*)
1913.....	386,310	(*k*)20,096	151,713	21,350	158,278	(*b*)
1914.....	377,843	(*k*)25,715	149,100	22,478	145,914	(*b*)
1915.....	358,107	(*k*)22,133	116,358	21,942	80,622	(*b*)
1916.....	269,374	(*k*)18,591	(*b*)	25,933	94,043	258
1917.....	211,847	(*k*)18,227	(*b*)	20,811	79,453	367

(*a*) From *Rivista del Servizio Minerario*. (*b*) Not reported. (*c*) Includes anthracite, lignite, fossil wood, and bituminous schist. (*d*) Does not include 680 tons lead and zinc ore. (*e*) Includes 560 tons lead-zinc ore. (*g*) Includes 290 and 300 tons lead-zinc ore, 1909 and 1910. (*i*) Besides 21,297 tons ore sold Natural. (*l*) Metallurgical coke only. (*k*) Crude, ground.

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MINERAL IMPORTS OF ITALY (a)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Arsenic. Kg.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
1902.....	80	1,200	1,636	1,020	1,170	516	13,732	15,216
1903.....	98	4,400	1,691	1,567	1,099	504	15,547	10,063
1904.....	131	3,700	2,174	2,604	1,875	271	15,260	6,891
1905.....	117	3,400	1,806	3,252	1,444	112	15,797	5,556
1906.....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
1907.....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908.....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909.....	293	4,890	2,285	3,826	2,094	386	25,250	11,120
1910.....	342	5,300	2,051	3,365	1,777	363	22,183	9.007
1911.....	358	5,500	3,892	4,238	2,024	741	24,467	7,942
1912.....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
1913.....	513	2,500	4,750	4,300	1,771	159	19,950	5,501
1914.....	198	3,500	2,710	2,924	1,409	280	15,002	3,810
1915.....	825	1,700	5,380	4,139	1,319	719	5,969	2,052
1916.....	155	2,700	5,428	1,090	1,398	985	6,606	2,943

Year.	Coal. (c)	Copper, Ore.	Copper, Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. Kg.	Graphite.
1903.....	5,546,823	9,459	649	9,588	24,566	1,396	63
1904.....	5,904,578	8,104	309	15,198	37,298	1,961	52
1905.....	6,437,539	6,879	486	18,188	30,684	5,768	107
1906.....	7,673,435	9,363	802	21,458	25,060	4,571	361
1907.....	8,300,439	18,023	888	28,937	15,939	4,443	267
1908.....	8,452,320	14,784	344	28,025	25,037	(d) 8,367	383
1909.....	9,303,506	11,303	630	22,391	9,137	(d) 8,311	141
1910.....	9,338,752	7,550	456	30,339	13,599	(d)13,188	229
1911.....	9,595,882	6,607	277	38,650	37,929	(d)12,712	246
1912.....	10,057,228	6,253	578	43,729	36,602	(d)10,545	403
1913.....	10,834,008	737	352	39,552	30,472	(d) 9,940	567
1914.....	9,758,877	850	*Nil*	28,422	21,939	(d)10,281	162
1915.....	8,369,029	571	*Nil*	54,718	14,081	(d) 6,389	1,506
1916.....	8,065,041	2,453	*Nil*	68,365	6,126	(d) 343	1,071
1917.....	.....	467	.....	93,640	.....	.....	.....
1918.....	.....	404	.....	80,533	.....	.....	.....

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbonate.	Mineral Paints.
	Ore.	Pig.		Ore. (c)	Metal and Alloys in Pigs.		
1903.....	5,937	126,756	206,036	689	5,398	768	859
1904.....	4,390	149,130	246,359	2,187	4,541	871	940
1905.....	4,745	136,077	276,311	465	6,764	686	974
1906.....	6,452	168,985	344,977	4,526	10,958	984	964
1907.....	22,046	231,042	362,567	4,342	9,231	953	1,119
1908.....	31,090	254,239	326,119	5,620	11,742	1,474	2,616
1909.....	28,150	246,730	416,354	3,003	10,011	1,132	1,713
1910.....	17,673	204,854	386,604	1,426	14,674	1,225	1,775
1911.....	50,554	234,770	392,703	6,042	20,187	1,077	1,756
1912.....	18,606	267,355	343,728	12,391	15,627	917	1,962
1913.....	8,026	221,688	326,231	9,552	11,494	682	2,410
1914.....	4,592	219,995	254,892	5,736	9,820	533	2,053
1915.....	7,607	240,535	261,468	6,181	17,326	183	1,811
1916.....	1,237	302,333	342,706	12,551	14,358	224	1,130
1917.....	313	315,953	226,937	4,838	32,373	.....	.....
1818.....	1,951	115,211	17,667	5,478	45,165	.....	.....

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Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia, and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver. *Kg.*	Slag, Metalliferous.
1904.....	652	69,233	217,162	14,846	1,663	25	15,885	3,821
1905.....	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(*d*)83,434	1,122
1909.....	540	88,929	478,199	15,547	5,333	2.2	(*d*)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(*d*)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(*d*)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(*d*)79,763	164
1913.....	1,200	115,374	529,776	17,407	9,454	0.3	(*d*)87,856	2,560
1914.....	1,112	116,276	513,998	16,382	3,708	*Nil*	102,090(*d*)	700
1915.....	1,812	111,426	456,901	21,977	900	4.3	(*d*)83,018	1,780
1916.....	1,991	97,747	431,425	19,878	*Nil*	42.0	(*d*)50,859	1,116
1917....	3,293	.....	.....	.....	.....	.....	.....	.....
1918.....	3,215	.....	.....	.....	.....	.....	.....	.....

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfrs.	Ore.	Oxide.	Spelter and Old.	Mnfrs.
1903....	24,753	43,480	638	2,288	130	46	1,416	4,551	4,461
1904....	27,747	32,283	613	2,170	150	362	1,124	5,202	4,168
1905....	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912....	49,284	54,634	529	2,627	157	*Nil*	2,550	11,955	5,833
1913....	52,332	67,418	574	2,973	144	5	2,983	12,448	6,071
1914....	48,115	59,850	310	2,744	110	*Nil*	2,348	10,518	4,302
1915....	53,191	71,730	2	4,245	38	*Nil*	1,833	12,843	1,087
1916....	45,212	85,649	103	2,916	32	*Nil*	1,376	17,766	1,017
1917....	.....	.....	.....	3,266	.....	.....	.....	19,383	.....
1918....	.....	.....	.....	2,341	.....	.....	.....	10,749	.....

MINERAL EXPORTS OF ITALY (*a*)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal (*e*)
1902.....	359	144	20,884	91	1,847	7,930	3,802	33,374
1903.....	314	222	24,303	35	901	6,325	4,089	29,219
1904.....	107	163	14,880	70	1,122	7,810	5,007	35,149
1905.....	132	236	23,740	162	2,255	8,445	4,194	38,555
1906.....	208	205	27,176	147	2,777	6,774	3,118	31,666
1907.....	115	142	26,036	152	1,330	4,477	3,224	40,769
1908.....	10	193	24,158	724	1,005	5,439	2,533	46,774
1909.....	8	527	21,978	125	1,704	7,534	3,525	51,343
1910.....	2	485	26,125	150	1,536	7,131	5,764	48,144
1911.....	*Nil*	517	28,455	353	1,347	10,742	9,440	40,800
1912.....	11	571	13,158	381	1,661	55,091	6,736	26,295
1913.....	*Nil*	672	6,645	234	1,373	55,908	5,161	192,002
1914.....	51	509	6,367	210	1,195	40,880	5,161	54,908
1915	3	148	6,720	3,288	1,702	40,430	627	79,090
1916.....	188	259	4,103	2,755	2,098	42,425	114	94,319

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Year.	Copper, Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1901.....	9	20	2,955	7,169	121,592	311	.....
1902.....	11	39	733	7,098	209,070	395	.....
1903.....	15	44	1,291	7,068	98,319	810	.....
1904.....	43	29	1,494	7,433	2,577	229	.....
1905.....	77	249	1,731	6,811	11,358	1,395	.....
1906.....	189	102	1,476	4,904	1,833	254	.....
1907.....	179	835	802	7,474	26,000	121	.....
1908.....	188	721	7,588	7,009	35,653	176	1,676
1909.....	233	1,211	15.452	8,125	46	209	1,480
1910.....	969	741	16.643	7,647	9,892	327	2,450
1911.....	130	157	14,144	7,633	22,851	290	3,390
1912.....	267	1,445	13,993	7,785	12,313	51	5,662
1913.....	285	609	16,440	8,329	9,660	555	6,895
1914.....	78	1,856	6,724	7,589	8,944	69	4,636
1915.....	2	62	1,072	6,508	157	40	2,576
1916.....	*Nil*	170	632	5,615	30	2	13

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver. *Kg.*
	Ore.	Lead Alloys, in Pigs.	Oxide and Carbonate.					
1901.....	3,977	4,463	410	2,913	1,290	301	114,210	42,325
1902.....	3,354	5,650	404	2,953	894	215	145,190	20,427
1903.....	5,041	2,911	426	3,305	2,942	222	144,910	9,486
1904.....	5,524	1,954	347	3,231	2,812	266	130,940	24,165
1905.....	4,311	976	310	3,632	3,519	243	116,040	25,947
1906.....	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907.....	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908.....	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909.....	1,037	782	211	4,310	2,979	714	103,895	(*d*)87,653
1910.....	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911.....	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912.....	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)28,275
1913....	16,950	577	314	4,166	4,171	993	161,118	(*d*)18,786
1914.....	15,403	189	687	4,220	8,569	760	124,860	(*d*)12,233
1915.....	3,817	14	339	3,458	1,809	853	108,991	(*d*)28,016
1916.....	9,871	4	1,582	2,766	*Nil*	767	31,135	(*d*) 4,898

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate (Crude).	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and Scrap.
1901....	3,261	377	116	59	414,018	202	187	103,020	140	349
1902....	3,615	446	346	259	439,242	236	174	114,894	122	338
1903....	4,929	482	781	492	461,289	173	180	116,449	116	591
1904....	4,458	376	363	230	437,067	171	151	126,393	483	263
1905....	9,844	214	424	159	381,128	285	107	117,810	173	434
1906....	6,990	253	80	133	336,339	303	81	144,244	687	639
1907....	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908....	12,122	583	37	57	330,093	180	173	122,456	395	984
1909....	17,163	517	464	163	329,233	85	126	123,936	212	983
1910....	10,488	321	98	45	344,513	164	245	127,315	957	845
1911....	8,274	180	168	15	398.592	166	319	133,471	1,577	616
1912....	19,563	243	27	7	376.387	83	359	152,840	2,165	1,232
1913..	8,251	337	50	10	351,339	152	394	144,644	1,318	1,566
1914....	7,822	123	179	12	259,920	179	313	89,776	1,219	1,234
1915....	715	94	*Nil*	5	293,908	36	364	59,734	2,560	86
1916....	495	31	*Nil*	108	326,435	100	388	80,180	1,294	129

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, leaf, and partly manufactured silver. (*e*) Includes coke.

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JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN (*a*)

Year.	Antimony.		Arsenic. *Kg.*	Coal.	Copper.	Gold. *Kg.*	Graphite	Pig. Iron.	Lead.
	Ore.	Metal.							
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(*b*)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(*b*)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909....	10	157	8,061	14,810,412	45,117	3,932	121	46,627	3,337
1910(*d*)	8	120	11,463	15,433,621	48,545	4,368	145	58,043	3,845
1911(*d*)	.....	97	5,760	17,632,710	53,401	4,690	114	63,986	4,125
1912....	.....	80	.....	19,515,285	62,939	5,233	149	56,265	3,764
1913....	.....	(*d*)21	.....	21,664,764	66,537	4,666	(*d*)665	57,513	3,779
1914....	.....	3,865	.....	22,296,738	70,481	7,068	574	73,909	4,563
1915....	8,390	8,347	14,885	20,490,702	75,415	8,293	666	64,897	4,764
1916....	12,402	**12,398**	.....	20,130,740	81,280	7,446	1,144	65,014	11,343
1917....	.....	**6,678**	.....	**26,510,187**	**91,201**	**7,077**	**1,329**	.....	**15,807**

Year.	Manganese Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1902....	10,844	39,056,820	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	34,850,129	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	50,724,174	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	51,573,754	1,519	25,569	349	(*b*)	82,886	24,652	26.0
1906....	54,339	47,132,800	3,037	36,038	336	(*b*)	76,247	27,589	77.0
1907....	20,586	60,005,957	1,721	56,166	456	(*f*)636,168	95,600	33,329	31.8
1908....	11,130	60,110,558	740	33,867	804	(*f*)659,202	123,180	33,149	25.7
1909(*d*) .	8,708	65,165,860	3,781	27,066	335	(*f*)696,049	127,917	36,317	22.8
1910(*d*) .	11,120	65,789,858	1,042	78,418	407	(*f*)696,474	141,613	43,155	23.0
1911....	9,787	63,843,601	2,271	73,879	1,021	(*g*)567,715	138,287	50,274	24.8
1912....	12,060	72,839,260	7,847	74,929	27	.....	152,385	55,005	35.6
1913....	2,313	67,557,322	19,047	114,589	.....	.....	146,180	59,481	379.0
1914....	17,076	112,163,530	38,252	115,840	.....	.....	150,958	59,850	245.0
1915....	25,870	124,277,191	57,723	67,536	38	.....	159,261	61,405	341.0
1916....	.....	120,111,856	114,389	91,102	204	.....	172,194	92,677	**255**.0
1917....	**51,366**	**119,706,678**	**121,609**	**121,349**	**2,000**	.....	**221,196**	**117,990**	**212**.0

(*a*) From *Résumé Statistique de l'Empire du Japan*, Tokio. (*b*) Not reported. (*d*) From reports of the Japanese Department of Agriculture and Commerce (*f*) Metric tons including Taiwan, fiscal years. (*g*) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

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MEXICO

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, 1909, and 1910, together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO (a)
(In metric tons or Mexican dollars)

Year.	Antimony.		Coal.	Copper.		Gold.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1898...	.....	5,932	118,553	13,146	10,362	$1,037,202	$6,493,735	$367,704	$294,730	$64,061
1899...	.....	10,382	113,192	223	25,293	335,849	7,017,286	183,474	115,961	266,782
1900...	.....	2,313	38,676	408	27,970	306,392	7,435,884	192,456	128,675	177,193
1901...	.....	5,103	17,281	5,576	33,818	284,722	8,324,681	210,431	178,803	81,744
1902...	1,218	1,280	3,406	6,101	63,609	303,979	9,079,371	129,899	78,295	40,658
1903 (c)	2,304	7,302	1,840	10,912	51,716	264,503	9,693,692	54,636	85,465	124,020
1904...	1,694	81	125	48,365	57,338	537,290	10,867,272	172,532	79,129	176,090
1905...	1,978	57	497	92,540	56,634	1,513,344	29,636,117	106,470	397,814	138,033
1906...	2,418	178	91	73,193	46,767	5,369,173	21,072,014	37,746	337,294	180,348
1907...	4,615	681	1,532	115,245	51,519	3,033,090	19,653,382	5,023,404	417,162	497,893
1908...	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944
1909...	4,115	31	235	136,031	32,580	2,346,279	40,725,976	23,678	85,110	250,741
1910...	3,730	6	120	129,568	54,061	2,526,444	46,189,613	37,723	46,803	168,162
1911...	4,131	121	101	109,627	60,493	1,945,660	48,113,427	8,153,293	38,031	141,640
1912...	3,491	15	50,777	103,129	60,439	1,121,333	42,686,667	1,479,292	43,481	119,357
1913...	2,340	(b)	40	19,500	29,438	785,531	32,918,172	470,758	54,417	172,188

Year.	Graphite.	Gypsum.	Lead.		Silver.					
			Ore.	Base Bullion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1898...	1,365	1,650	(b)	60,918	$11,048,358	$37,137,599	$16,588,789	$1,663,501	$257,342	$46,488
1899...	2,305	1,050	1	67,441	10,766,099	37,585,911	5,580,834	1,929,085	76,942	4,819
1900...	2,561	1,600	468	74,944	12,495,524	41,468,745	22,679,655	1,893,646	67,607	87,880
1901...	762	800	(b)	79,097	9,615,939	36,348,374	12,038,158	2,141,685	259,282	93,543
1902...	1,434	(b)	118	107,366	4,108,088	45,796,576	17,753,526	1,978,919	108,344	132,093
1903 (c)	1,404	(b)	11	100,532	11,781,048	48,276,797	16,167,673	1,642,627	135,561	289,900
1904...	970	(b)	1	95,010	11,000,869	45,430,020	7,251,132	1,392,356	171,452	202,594
1905...	970	27	1	101,196	8,505,834	63,564,789	20,335,297	736,228	438,094	29,012
1906...	3,915	(b)	(b)	73,699	9,619,763	63,057,152	42,390,357	595,112	434,885	(b)
1907...	3,202	(b)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	(b)
1908...	1,076	(b)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,849	(b)
1909...	1,704	(b)	1	118,186	8,057,189	66,789,716	91,006	557,520	78,688	(b)
1910...	2,332	1	355	120,662	6,793,896	70,272,894	72,891	208,300	52,053	(b)
1911...	2,974	(b)	397	124,605	6,766,644	78,515,378	8,901	235,410	159,170	*Nil*
1912...	2,865	(b)	59	109,717	5,769,575	82,047,500	8,645	(d)	347,277	*Nil*
1913...	1,057	(b)	1,386	55,530	2,108,805	63,232,843	2,585,701	423,625	418,522	(b)

(a) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (b) Not reported. (c) Figures for 1904 are from *Anuario Estadistico de la Republica Mexicana* for 1904. (d) 11 metric tons.

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NORWAY

The official statistics of mineral production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY (*a*)

(In metric tons or dollars; 1 Krone = 27 cents)

Year.	Apatite. (*b*)	Chrome Ore.	Copper.		Feldspar.	Gold. Kr.	Iron.		
			Ore.	Ingot.			Ore and Conc.	Pig and Cast.	Bars and Steel.
1904 ...	1,456	154	36,891	1,342	20,835	*Nil.*	45,328	350	395
1905 ...	2,522	*Nil.*	37,045	1,153	22,508	*Nil.*	46,582	474	253
1906. ..	3,482	*Nil.*	32,203	1,333	23,896	$5,400	109,259	257	317
1907 ...	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908. ..	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	.....	.....
1909 ...	1,364	*Nil.*	42,612	1,594	36,439	8,000	40,389	.....	.....
1910 ...	703	.....	46,308	1,814	39,507	5,000	102,447	.....	.....
1911 ...	897	.....	34,705	1,650	34,864	.....	220,524	316	.....
1912 ...	1,168	115	60,018	2,130	39,844	.....	408,092	309	.....
1913 ...	757	.....	70,349	2,741	40,842	2,200	544,686	346	.....
1914 ...	750	81	57,951	2,860	27,967	.....	652,273	6,909	.....
1915 ...	1,901	350	56,097	2,828	8,778	.....	714,917	8,741	.....
1916 ...	2,236	2,757	28,670	1,614	12,811	.....	417,899	6,233	.....

Year.	Molybdenite.	Nickel.		Pyrite, Iron, and Copper.	Rutile.	Silver.		Zinc Ore. (*c*)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1904.....	30	5,352	75	133,603	25	1,297	8,064	42
1905.....	46	5,477	73	162,012	35	1,570	7,100	4,241
1906.....	1,026	6,081	77	197,886	55	1,565	6,370	3,308
1907.....	30	5,781	81	236,038	55	1,756	6,700	400
1908.....	35	5,190	81	269,129	83	2,262	7,470	2,435
1909.....	30	5,770	62	282,606	.....	2,729	7,780	983
1910.....	.....	19,639	69.8	329,642	116	.....	.....	2,219
1911.....	.....	27,743	172	369,055	76	2,892	7,635	2,240
1912.....	21	30,697	390	464,326	100	4,027	8,400	40
1913.....	12	49,990	690	441,291	77	5,411	9,400	897
1914.....	(*d*)83	48,529	794	414,886	30	7,372	12,904	243
1915.....	(*d*)97	77,018	892	513,335	170	8,431	11,900	1,829
1916.....	(*d*)137	79,903	808	295,354	103	7,515	9,000	1,017

(*a*) *Tabeller vedkommende Norges Bergværksdrift*, and *Statistisk Aarbok for Kongeriket Norge*
(*b*) Exports which represent production. (*c*) Includes lead ore. (*d*) Includes wolframite.

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MINERAL IMPORTS OF NORWAY (a)

(In metric tons)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal, and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1904.....	54,953	12,845	21,049,128	688	866	18,891	24,094
1905.....	(c)	13,797	20,973,608	882	1,146	20,828	27,740
1906.....	63,000	11,676	21,478,000	906	783	20,197	26,015
1907.....	79,810	16,647	24,274,260	(f) 954	1,107	23,345	32,764
1908.....	87,255	44,991	(e)2,073,907	(f)1,013	1,157	26,106	31,849
1909.....	79,786	57,768	(e)2,095,611	(f) 869	1,095	23,167	31,215
1910	105,453	20,100	(e)2,159,717	(f)1,118	1,406	28,034	34,623
1911.....	100,493	17,892	(e)2,187,246	(f)1,229	1,780	26,569	36,172
1912.....	103,923	27,960	(e)2,474,253	(f)1,567	2,116	29,908	44,756
1913.....	107,633	31,989	(e)2,482,424	(f)1,769	2,035	30,682	49,442
1914.....	85,185	42,967	(e)2,764,061	(f)3,441	2,337	32,254	44,951
1915.....	682,298	27,347	(e)3,095,049	(f)2,750	2,750	39,670	64,863
1916.....	644,723	87,438	(e)2,833,063	(f)1,374	2,148	34,712	60,239

Year.	Iron and Steel *Continued.*						Lead in Pigs and Sheets.
	Anchors, Cables, and Chains.	Rails.	Nails, Spikes, and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1904	2,109	5,814	1,071	1,610	42,013	5,462	498
1905	2,224	6,566	1,222	1,436	42,203	44,414	448
1906	2,585	8,086	1,012	2,018	48,969	45,959	727
1907	2,653	6,989	991	1,592	47,758	48,965	887
1908	2,535	12,180	1,032	1,628	49,569	52,594	529
1909	1,750	9,051	1,049	1,911	46,195	55,198	536
1910	2,131	5,512	852	3,203	56,898	60,282	838
1911	2,327	15,312	1,129	3,908	65,847	72,170	939
1912	2,591	12,276	1,313	4,239	84,525	86,552	1,142
1913	2,479	15,291	1,613	3,197	76,158	86,411	1,054
1914	2,651	21,834	1,340	2,638	75,145	91,496	1,079
1915	2,260	32,315	1,644	1,645	112,694	111,546	1,482
1916	3,198	17,601	3,074	2,249	84,622	97,097	1,517

Year.	Lead-white and Zinc Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Salt-peter.	Soda.	Sulphur. (b)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1904 ...	1,898	50,543	477	153,699	321	3,197	12,181	176	940
1905 ...	1,309	43,860	393	137,800	1,048	3,704	10,240	134	967
1906 ...	1,149	41,546	396	167,300	776	4,334	11,465	261	2,791
1907 ...	1,245	44,231	588	163,458	1,004	5,819	11,412	332	3,549
1908 ...	1,201	64,680	504	177,349	935	7,850	12,281	323	1,418
1909 ...	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910 ...	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911 ...	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912 ...	1,864	80,023	541	214,817	418	15,877	13,911	439	9,636
1913 ...	2,502	79,253	572	214,987	522	16,255	15,411	333	13,560
1914 ...	2,293	87,268	942	201,036	141	20,325	10,347	662	17,402
1915 ..	2,178	55,945	1,111	263,107	31	23,798	6,804	1,029	31,811
1916 ...	2,434	103,902	1,463	316,166	9	25,860	7,262	741	28,891

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MINERAL EXPORTS OF NORWAY (a)
(In metric tons)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron.
		Ore.	Ingot.	Scrap.			Ore.
1903.....	1,795	3,448	1,930	888	(d)18,640	11,417	41,575
1904.....	1,456	2,673	1,124	785	20,835	9,414	45,434
1905.....	2,522	3,393	958	968	20,696	12,000	60,558
1906.....	3,482	84	875	964	19,669	13,248	81,398
1907.....	1,830	1,581	1,033	1,644	29,399	13,780	132,593
1908.....	1,771	156	1,260	385	29,896	11,097	110,425
1909.....	1,365	3,245	1,335	543	33,692	13,620	38,933
1910.....	703	241	1,377	583	39,507	13,114	88,715
1911.....	500	924	1,091	575	34,864	16,982	180,932
1912.....	.....	423	1,551	366	39,844	11,642	404,990
1913.....	.....	74	2,644	167	40,843	12,149	568,763
1914.....	.....	0.1	2,558	502	27,966	3,096	467,796
1915.....	.....	438	2,691	293	12,607	576	425,892
1916.....	.....	2,175	1,430	359	9,570	1,131	404,700

Year.	Iron (*Continued*).				Nickel Ore.	Pyrite.	Zinc.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1903.....	6,350	10	6,504	200	*Nil.*	118,148	.....
1904.....	10,152	13	7,477	167	30	116,550	.....
1905.....	9,920	34	8,725	88	220	147,155	.....
1906.....	7,362	8	6,786	21	*Nil.*	164,119	.....
1907.....	4,652	7	5,879	31	11	187,983	.....
1908.....	6,787	2	4,839	17	*Nil.*	218,851	.....
1909.....	11,429	24	5,187	11	3	216,767	.....
1910.....	13,455	5	6,878	34	.....	343,073	.....
1911.....	12,569	40	5,692	271	(g)385	343,850	.....
1912.....	16,889	.....	5,326	296	(g)594	424,121	.....
1913.....	26,917	.....	3,972	150	.....	460,912	10,538
1914.....	14,586	17	4,012	1,416	(g)696	403,255	16,517
1915.....	12,961	.....	6,001	2,005	(g)761	513,901	22,617
1916.....	21,355	.....	4,697	1,211	723	253,361	28,150

(a) From *Tabeller vedkommende Norges Bergvaerksdrift* and *Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Includes a small quantity of fluorspar (e) In metric tons. (f) Includes a quantity of sheet aluminium. (g) Metallic nickel.

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PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL (*a*)

(In metric tons)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite). (*c*)	Copper.			
				Copper-Iron Pyrite. (*c*)	Other Ores.	Cement.	Matte.
1901.....	(*b*)	527	16,000	443,397	(*b*)	2,061	(*b*)
1902.....	68	736	11,000	413,714	655	2,205	(*b*)
1903.....	83	698	8,063	376,177	527	2,448	(*b*)
1904.....	31	1,370	12,805	383,581	297	(*b*)	(*b*)
1905.....	84	1,562	11,449	352,479	210	2,148	(*b*)
1906.....	481	1,322	6,762	350,746	196	3,634	(*b*)
1907.....	383	1,538	8,824	241,771	2,478	2,942	298
1908.....	76	1,655	4,614	81,417	15,455	3,041	564
1909.....	6	1,420	6,274	12,337	1,321	3,037	309
1910.....	25	974	8,149	19,161	230	3,768	230
1911.....	.....	887	10,610	15,287	517	3,979	283
1912.....	100	1,006	15,626	120,148	1,309	4,028	.....
1913.....	19	925	25,037	13,550	.....	4,177	.....
1914.....	*Nil.*	960	29,680	40,850	219,140	3,200	.....

Year.	Gold. *Kg.*	Iron Ore.	Lead Ore (Galena).	Manganese Ore	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1901	2.0	21,599	445	904	(*c*)	31	90
1902	2.0	19,914	1,651	(*b*)	(*c*)	24	234
1903	1.3	15,200	830	30	(*c*)	(*b*)	228
1904	*Nil.*	12,488	291	(*b*)	(*c*)	51	290
1905	*Nil.*	3,200	50	(*b*)	(*c*)	20	358
1906	*Nil.*	(*b*)	511	22	(*c*)	22	570
1907	10.5	(*b*)	510	1,374	123,393	35	226
1908	57.0	(*b*)	481	(*b*)	24,522	28	106
1909	25.0	(*b*)	736	(*b*)	272,398	18	673
1910	4.1	3,360	919	(*b*)	293,745	9	948
1911	3.6	19,541	1,185	6	267,486	86	908
1912	3.5	35,210	495	6	481,295	173	1,227
1913	1.0	49,182	1,046	(*b*)	377,533	254	1,089
1914	*Nil.*	6,639	2,163	(*b*)	32,554	370	615

(*a*) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas, except for 1904 to 1906, inclusive, and 1913 and 1914, which are from official Government reports. The mineral production of the country is identical with exports, except in the case of coal. (*b*) Not reported. (*c*) Consumed in the country. (*d*) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

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RUSSIA

The mineral and metallurgical production of Russia, according to the best statistics available to MINERAL INDUSTRY, is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA (*a*)

(In metric tons; 1 metric ton = 61.05 poods)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (*b*)	Pig Iron.	Lead.	Manganese Ore.
1901..	4,398	22,169	16,526,652	8,467	$22,763,967	2,866,779	156.0	522,395
1902..	4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
1903..	5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
1904..	7,502	26,575	19,608,831	9,335	24,627,537	2,972,115	90.3	430,090
1905..	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906..	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907..	9,398	(*g*)26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(*g*)1,003,528
1908..	10,911	(*g*)10,950	(*g*)25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
1909..	(*h*)13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
1910..	(*h*)10,936	1,362	(*f*)23,105,628	(*f*)22,619	(*f*) 35,566,045	(*f*)3,042,046	.....	668,050
1911..	17,071	1,238	28,007,239	(*f*)25,097	(*f*) 34,550,609	3,593,000	.....	(*i*) 636,180
1912..	18,138	21,277	30,641,163	33,513	28,852,881	3,726,000	.....	903,226
1913..	18,594	.....	32,206,000	34,282	22,199,000	3,801,273	.....	1,130,000
1914..	.....	.....	.....	32,250	24,300,000	.....	.....	652,354
1915..	.....	.....	.....	35,470	.....	2,792,516	.....	.....
1916..	.....	.....	.....	.....	.....	3,861,600	.....	.....

Year.	Petroleum.	Phosphate Rock.	Platinum. *Kg.*	Pyrite.	Quicksilver.	Salt.	Silver *Kg.*	Sulphur.	Zinc.
1900..	9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
1901..	10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
1902..	10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
1903..	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904..	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905..	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906..	8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
1907..	9,098,931	(*g*)15,457	5,903	18,316	(*g*)132	1,873,171	7,843	(*d*)57	10,409
1908..	8,732,301	(*g*)14,976	4,883	56,345	147	1,879,717	9,595	(*d*)85	9,960
1909..	8,961,507	(*h*)21,326	5,120	(*f*)46,078	.....	2,259,690	(*h*)15,415	.....	7,644
1910..	8,952,793	(*h*)24,883	5,471	(*f*)55,980	.....	2,047,980	(*h*)14,841	.....	(*f*)8,631
1911..	9,152,315	(*h*)25,503	(*f*)5,432	113,054	.....	2,013,765	15,512	.....	(*f*)9,652
1912..	9,249,600	.....	5,523	123,990	.....	.....	.....	.....	8,763
1913..	9,474,876	.....	4,897	.....	.....	.....	.....	.....	7,610
1914..	9,099,494	.....	4,880	.....	.....	.....	.....	.....	.....
1915..	.....	.....	3,374	.....	.....	.....	.....	.....	.....

(*a*) From official sources. (*b*) The value of gold is taken at $20.67 per ounce. (*d*) Includes sulphide ore. (*f*) Statistics of Association of Russian Manufacturers and Traders. (*g*) St. Petersburg Scientific Committee. (*h*) The Russian Year Book, Dr. Kennard, London. (*i*) Exports. (*j*) *Mineral Resources of U. S.*

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SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA (*a*)

(In metric tons)

Year.	Antimony Ore.	Bismuth.		Copper Ore.	Copper. (*c*)	Gold. (*b*)	Silver. (*d*)	Tin Ore.	Tungsten Ore.
		Metal.	Ore.						
1907....	2,279	249	153.379	.....	3,469	$3,551	3,696	27,668	(*e*)500
1908....	734	259	160.305	.....	3,027	21,617	156.5	29,938	170
1909....	.....	89	236.762	.....	3,097	.....	155.4	35,566	170
1910....	.....	97	311.060	.....	3,212	.....	143	38,548	207
1911....	312	(*g*)415	1,208.689	.....	2,950	22,313	128.0	37,073	297
1912....	91	(*g*)478	.....	.....	4,707	23,038	123.9	38,614	472
1913....	62	391	32	.....	4,020	175,000	81.3	44,597	283
1914....	186	(*g*)437	.....	4,793	3,874	.....	72	37,259	276
1915....	17,923	(*g*)663	.....	17,945	5,839	.....	78	36,324	755
1916....	27,414	.....	.....	23,860	5,151	.....	.....	35,543	3,035

(*a*) From a British Consular report and Revista de Aduanas. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and concentrate. (*d*) Includes ingots, ore, and sulphide. (*e*) U. S. Geol. Surv. (*g*) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL (*a*)

(In metric tons or dollars) (*d*)

Year.	Agate.	Carbonado. *Carats*	Copper Ore.	Diamonds. *Carats.*	Gold.	Manganese Ore.	Mica	Monazite.	Platinum	Precious Stones. (*b*)	Rock Crystal.
1909(*e*)	.....	177,572	(*c*)	58,862	$2,252,900	240,774	.....	6,462	*Nil*	$56,338	.....
1910(*e*)	34	13,848	(*c*)	14,366	1,954,674	253,953	1.4	5,437	*Nil*	745	.....
1911(*e*)	112	63,400	1	103,567	2.850.370	173,941	9.0	371	*Nil*	135,220	24
1912(*e*)	103	47,998	.....	139,175	2,676,950	154,870	11.5	3,398	*Nil*	74,597	45
1913..	.....	.....	.....	.....	2,692,154	122,300	.....	1,437	*Nil*	174,066	.....
1914..	.....	.....	.....	.....	2,127,515	183,600	15.3	600	*Nil*	21,022	.....
1915(*e*)	.....	$119,994	.....	11,803	2,390,719	288,671	11.9	439	*Nil*	44,024	*Nil*
1916(*e*)	.....	457,941	.....	84,004	.....	503,130	53.7	375	$4,003	116,784	1
1917..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*a*) As reported by the *Brazilian Review*. (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*d*) The par exchange value of the *Mil Reis* in 1907 was $0.546 U.S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103, and in 1907, $3.301. (*e*) Reported by U. S. Consul at Rio de Janeiro.

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MINERAL PRODUCTION OF CHILE (*a*)
(In metric tons)

Year.	Borax.	Coal.	Iron Ore.	Copper.	Gold. *Kg.*	Guano.	Iodine.	Salt.	Silver. *Kg.*	Sodium Nitrate.	Sulphur.
1903..	16,879	827,112	.....	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904..	16,733	751,628	.....	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905..	19,612	793,927	.....	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906..	28,996	932,488	.....	25,829	1,135	4,709	331	17,116	12,211	1,822,144	4,598
1907..	28,374	832,612	.....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	.....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	.....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	.....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	.....	36,420	437	17,841	437	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	.....	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913(*e*)	**50,225**	**1,283,450**	**14,100**	42,264	**1,147**	.....	**437**	.....	39,564	2,666,835	**6,647**
1914(*e*)	34,203	266,962	63,505	45,682	**1,017**	.....	489	.....	**36,581**	1,846,783	**10,008**
1915(*e*)	.....	.....	.....	52,081	.....	.....	.....	.....	.....	2,023,562	.....
1916(*e*)	.....	.....	.....	71,430	.....	.....	.....	.....	.....	.....	.....

(*a*) From *Estadistica Minera de Chile.* (*b*) The combined output of the years 1894 to 1902, inclusive was 86,892 tons.. (*c*) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (*e*) Exports. (*f*) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU (*a*)
(In metric tons)

Year.	Bismuth.	Borate.	Coal. (*b*)	Copper.	Gold. *Kg.*	Lead.	Petroleum.	Quicksilver. *Kg.*	Silver. *Kg.*	Salt.	Tungsten Ore.	Vanadium Ore.
1910...	24	2,351	307,320	27,347	708.0	1,866	167,712	350	252,565	17,594	12	.....
1911...	24	1,923	324,000	27,735	741.2	2,208	195,276	560	289,383	24,867	48	.....
1912...	51	1,674	278,927	26,970	1,435.0	4,050	233,600	400	324,352	23,292	195	.....
1913...	25	2,001	273,945	27,776	1,435.0	3,927	276,147	460	299,132	24,433	290	.....
1914...	11	1,263	283,860	27,090	1,500.0	3,048	252,666	700	286,600	25,933	196	14
1915...	.....	510	290,743	34,727	1,690.0	2,696	363,162	920	294,425	25,729	375	3,145
1916...	.....	1,289	319,063	43,078	1,907.0	2,038	345,758	2,101	335,529	.....	523	3,448
1917...	1	800	353,595	45,176	1,887.0	1,272	347,092	.....	337,928	.....	406	4,083

(*a*) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (*b*) Includes asphaltum and bituminous schist.

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SPAIN

The following tables record the mineral and metal production of Spain as reported by official authorities:

MINERAL PRODUCTION OF SPAIN (*a*)
(In metric tons)

Year.	Aluminous Earths.	Antimony Ore.	Arsenic.	Asphaltum.	Asphalt, Rock.	Barytes.	Cement, Hydraulic.	Coal.	
								Anthracite.	Bituminous.
1904...	925	245	400	3,463	3,761	453	286,737	163,275	2,903,771
1905...	221	77	1,140	5,805	5,725	290	296,605	159,517	2,912,466
1906...	386	180	1,114	6,229	7,794	330	299,294	113,747	3,095,043
1907...	1,209	205	1,500	8,643	8,219	314	329,926	164,498	3,531,337
1908...	60	124	2,004	9,231	12,373	334	343,001	188,463	3,696,653
1909...	35	(*b*)	506	6,582	5,284	422	472,909	198,302	3,662,573
1910...	400	15	444	8,473	7,795	476	484,161	211,958	3,600,056
1911(*f*)	461	100	331	3,495	6,500	635	486,085	209,227	3,454,394
1912...	.....	500	.....	5,387	.....	1,096	.....	226,663	3,625,666
1913(*h*).	.....	.....	.....	5,582	.....	3,049	.....	232,517	3,783,214
1914(*i*)	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915...	.....	300	.....	4,521	.....	4,218	.....	222,621	4,135,919
1916...	256	515	.....	7,136	.....	10,508	.....	268,093	4,847,475
1917(*i*).	470	502	.....	1,817	.....	10,147	.....	324,756	5,042,213

Year.	Coal (*Continued*).		Coke.	Copper Ore.		Copper.			Fluorspar.
	Lignitic.	Briquets.		Argentiferous.	Pyritic.	Fine.	Matte.	Precipitate.	
1904...	100,773	307,630	432,726	(*b*)	2,624,512	(*b*)	8,117	29,494	(*b*)
1905...	168,994	290,830	448,073	(*b*)	2,621,054	(*b*)	8,243	17,988	(*b*)
1906...	189,048	311,328	435,808	(*b*)	2,888,778	(*b*)	9,068	19,200	70
1907...	191,001	355,718	476,360	(*b*)	3,182,645	(*b*)	9,886	20,887	270
1908...	223,160	296,216	477,059	(*b*)	2,985,779	(*b*)	205	19,599	253
1909...	265,019	(*b*)	500,909	(*b*)	2,955,254	(*b*)	2,077	16,641	246
1910...	245,518	474,891	521,078	(*b*)	3,231,418	85	2,684	14,056	180
1911(*f*)	252,051	478,143	516,342	(*b*)	3,284,184	(*g*)76	1,910	12,353	499
1912...	283,480	465,106	489,558	.....	3,366,165	.....	1,861	.....	265
1913(*h*).	276,791	486,228	595,677	.....	2,265,642	.....	3,049	.....	351
1914(*i*).	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915...	328,213	147,600	.....	23,068	1,464,350	.....	2,001	.....	370
1916...	473,106	.....	.....	25,190	1,748,742	.....	.....	.....	.....
1917(*i*).	637,841	.....	.....	83,501	1,817,839	.....	.....	.....	250

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentiferous.	Non-argentiferous.	Pig.	Wrought Iron.	Iron and Steel, Worked.		Ore.	Metal.
1904...	122,109	7,964,743	283,819	50,858	186,705	1,700	177,104	57,956
1905...	152,027	9,007,245	305,462	11,366	223,545	720	160,381	56,361
1906...	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907...	(*b*)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(*b*)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	218,410	570	161,496	43,552
1910...	46,161	8,666,795	373,322	59,133	201,798	1,496	150,592	38,548
1911(*f*)	.....	8,773,691	408,667	11,166	264,930	4,469	156,569	40,379
1912...	1,588	9,133,007	366,136	.....	.....	4,920	93,850	49,212
1913(*h*).	.....	9,861,668	350,433	.....	.....	5,263	23,600	15,704
1914(*i*).	.....	.....	.....	.....	.....	.....	.....	.....
1915...	.....	5,617,839	.....	.....	.....	4,700	2,935	.....
1916...	.....	5,856,861	.....	.....	.....	1,500	7,371	.....
1917(*i*).	.....	5,551,071	.....	.....	.....	1,220	13,218	.....

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Year.	Lead (Non-argentiferous).		Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrites (Iron).	Pyrites (Arsenical).	Quicksilver.	
	Ore.	Metal.						Ore.	Metal.
1904 ...	93,230	127,906	18,732	(b)	3,305	161,841	3,510	27,185	1,130
1905 ...	105,113	129,332	26,020	(b)	1,370	179,079	4,790	26,485	853
1906 ...	105,095	131,614	62,822	164	1,300	189,243	2,434	28,965	1,568
1907 ...	103,632	135,066	41,504	114	3,547	225,830	3,423	28,789	1,212
1908 ...	126,667	134,321	16,745	400	4,483	263,451	5,533	42,210	1,068
1909 ...	137,050	136,441	7,827	418	1,387	258,931	3,235	37,398	1,393
1910(f).	216,738	151,975	8,607	759	2,840	294,184	1,461	22,714	1,114
1911...	165,843	149,540	5,607	622	3,520	344,879	1,056	19,940	1,494
1912...	190,162	183,400	17,400	.....	3,292	421,070	.....	21,898	1,256
1913(h).	279,078	173,125	21,594	.....	3,548	926,913	.....	19,960	1,246
1914(i).	.....	.....	8,965	.....	.....	.....	.....	.....	924
1915 ...	285,266	.....	14,328	1,500	.....	730,568	.....	20,717	1,241
1916 ...	260,283	.....	14,178	800	14,111	953,679	.....	19,799	1,200
1917(i).	240,368	.....	57,474	780	28,148	376,918	.....	18,705	.....

Year.	Salt.	Silver.		Soapstone.	Sulphur.		Tin Ore, Dressed.	Topaz. Kg.	Tungsten Ore.	Zinc.		
		Ore.	Metal. Kg.		Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1904..	543,658	303	7,418	5,165	40,389	605	229	....	60	156,329	5,887	2,913
1905..	493,451	540	123,607	4,364	38,153	610	209	....	375	160,561	6,184	2,936
1906..	541,978	470	126,424	3,609	28,965	700	86	171	430	170,384	6,209	2,639
1907..	605,895	702	127,435	13,875	27,054	3,612	315	266	386	191,853	6,144	2,485
1908..	822,677	441	129,881	4,730	13,872	2,988	838	(b)	226	156,233	6,357	2,693
1909(f	800,703	388	143,403	5,583	21,750	3,429	(e) 1,555	(b)	129	163,522	9,625	(b)
1910..	678,057	217	129,157	4,665	30,113	3,834	35	149	153	156,113	8,557	2,722
1911..	654,767	858	110,082	5,647	40,662	6,580	34	.....	96	162,140	2,904	3,429
1912(h	23,292	668	143,400	.....	42,344	4,592	5,079	.....	169	175,311	8,451	.....
1913(i	26,238	405	266,606	.....	62,653	7,499	6,626	.....	235	174,831	7,935	.....
1914..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915..	305,035	210	.....	963	28,937	.....	102	.....	511	81,922	.....	.....
1916..	348,938	275	.....	3,561	46,923	.....	86	.....	455	166,053	.....	.....
1917(i	309,413	96	.....	3,450	84,979	.....	77	.....	546	123,485	.....	.....

(a) Figures are from *Estadistica Minera de España*. (b) Not reported. (e) Undressed tin ore (f) *Revista Minera*, June 24, 1911. (g) Blister copper 18,295 tons, copper sulphate 15,893 tons (h) *Revista Minera*, Apr. 24, 1914. (i) *Revista Minera*.

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SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN (a)
(In metric tons)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. *Kg*
			Ore.	Ingot.	Sulphate.			
1905.....	139	322,384	39,255	1,385	1,029	19,224	40	55.0
1906.....	167	296,980	19,655	1,209	562	21,014	37	20.3
1907.....	131	305,338	21,957	1,577	782	20,244	33	28.1
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	1.8
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.0
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.6
1913.....	159	363,965	5,458	4,315	428	37,878	88	25.4
1914.....	.....	366,639	8,839	4,692	651	20,818	56	84.3
1915.....	.....	412,261	10,549	4,561	.....	12,105	87	37.3
1916.....	.....	414,825	13,895	3,181	.....	12,724	194	18.0
1917.....	.....	442,633	13,579	4,423	.....	18,533	123	11.0

Year	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms, Unwelded	Bars, Rods, etc.	Iron Sulphate.	Bessemer.	Martin.	Crucible and Electro.
1905....	4,364,833	539,437	182,640	369,771	144	78,204	288,675	1,319
1906....	4,501,656	604,789	178,298	391,352	170	84,633	311,435	1,457
1907....	4,478,917	615,778	174,405	417,535	159	77,036	341,893	1,287
1908....	4,712,494	567,821	152,256	390,957	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	308,823	182	63,351	248,757	1,518
1910....	5,549,987	603,939	151,713	431,722	236	97,583	372,451	2,215
1911....	6,150,718	634,392	146,722	423,170	156	93,853	372 705	4,309
1912....	6,699,226	699,816	148,828	470,352	335	107,254	307,637	3,941
1913....	7,475,571	730,257	158,472	516,561	320	115,839	404,118	5,661
1914....	6,586,630	639,718	116,074	441,060	158	93,210	469,387	4,594
1915....	6,883,308	760,701	119,629	537,922	.....	91,070	503,766	5,582
1916....	6,986,298	732,734	119,197	837,361	.....	75,800	525,500	9,388
1917....	6,217,172	828,969	114,429	807,050	.....	77,854	491,257	11,889

Year.	Lead.	Manganese Ore.	Pyrite.	Silver-Lead Ore.	Silver. *Kg.*	Nickel Ore.	Zinc Ore.
1905.....	576	1,992	20,762	8,397	606	.....	56,885
1906.....	753	2,680	21,827	1,938	938	.....	52,552
1907.....	813	4,334	27,113	1,987	929	.....	50,884
1908.....	277	4,616	29,569	2,058	630	.....	40,077
1909.....	166	5,212	16,104	1,721	512	.....	43,760
1910.....	355	5,752	25,445	2,700	30	.....	49,453
1911.....	1,134	5,377	30,096	2,999	1,289	.....	51,342
1912.....	1,073	5,101	31,835	2,877	962	.....	50,036
1913.....	1,235	4,001	34,319	3,222	1,037	.....	50,752
1914.....	1,396	3,643	33,313	3,110	1,074	156	42,279
1915.....	1,918	7,607	76,324	2,671	754	1,642	55,937
1916.....	2,076	8,894	97,848	3,707	1,180	3,561	60,700
1917.....	3,174	19,873	142,366	3,709	1,784	4,991	51,312

(a) From *Sveriges Officiella Statistik Bergshanteringen.*

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MINERAL IMPORTS OF SWEDEN (a)
(In metric tons or dollars; 1 krona = 27 cents)

Year.	Asbestos. (c)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. Kg.	Cement.	Chalk, White, Unground. Hectoliters.	Coal.
1904....	356	6,243	392	299	77	10,128	10,526	10,115	3,367,826
1905....	140	4,760	264	294	82	18,788	10,999	13,305	3,297,485
1906....	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907....	672	8,213	610	490	85	6,784	17,801	(g) 860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	(g) 419	4,427 507
1909....	383	7,922	529	365	76	10,280	12,944	(g) 512	4,084,055
1910....	671	7,406	625	379	92	10,912	15,438	(g) 473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	(g) 605	3,964,870
1912....	635	7,645	644	434	100	9,319	17,438	(g) 422	4,293,719
1913....	1,094	6,809	610	470	120	11,211	12,120	(g) 2,337	4,878,854
1914....	789	7,348	730	462	127	21,064	14,769	(g) 2,332	4,626,932
1915....	895	10,567	1,665	825	211	14,904	15,579	(g) 4,789	3,836,097
1916....	896	6,331	3,308	499	72	17,792	15,685	(g) 732	4,027,141
1917....	.....	.....	.....	.....	.....	.....	5,221	.....	1,500,425
1918....	.....	.....	.....	.....	.....	.....	5,810	.....	1,926,711

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Pig Iron and Scrap.	Lead. (c)	Litharge.	Phosphorus. Kg.	Platinum. Kg. (c)
1902....	5,803	147	173	6,754	63,129	2,587	173	68,441	130
1903....	5,013	132	173	8,795	76,152	2,732	237	112,659	116
1904....	6,807	221	213	8,868	90,101	2,959	250	47,421	84
1905....	5,677	271	205	11,270	87,843	2,962	230	69,526	105
1906....	7,371	284	255	13,496	108,194	3,596	212	79,048	133
1907....	6,945	336	375	15,037	115,174	3,384	210	77,936	109
1908....	6,849	308	540	11,644	109,837	3,964	248	107,301	117
1909....	5,639	428	443	14,212	99,510	3,222	217	88,241	72
1910....	9,710	438	398	15,816	118,373	3,453	267	99,145	77
1911....	8,817	459	398	14,505	114,837	2,901	270	77,837	103
1912....	7,767	474	513	19,237	140,115	3,019	316	88,411	84
1913....	10,265	655	576	23,222	172,489	3,394	327	92,487	126
1914....	13,537	495	334	13,210	163,290	3,022	474	140,040	90
1915....	14,901	915	851	9,244	166,026	2,296	538	176,650	282
1916....	12,642	1,398	719	14,353	194,100	5,945	677	103,726	234

Year.	Potassium.				Quicksilver. Kg.	Salt.		Silver.	
	Chloride.	Cyanide. Kg.	Hydrate.	Carbonate.		Crude.	Refined.	Bullion and Mfrs. Kg.	Specie.
1904.....	1,594	3,237	2,234	1,184	5,768	84,237	4,615	19,034	$86,891
1905.....	1,296	3,437	2,251	1,133	4,609	87,677	3,889	14,425	82,620
1906.....	1,986	4,106	2,486	1,082	5,535	88,341	3,700	19,020	93,990
1907.....	1,840	4,150	2,484	1,269	8,930	(h) 835,190	18,821	26,834	52,463
1908.....	2,190	3,563	2,835	1,209	7,299	(h) 903,633	24,394	20,149	94,368
1909.....	1,805	3,808	2,627	1,312	6,077	(h) 766,195	24,143	17,495	154,265
1910.....	2,335	4,272	2,767	1,346	7,079	(h) 766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	(h 736,935	26,026	15,175	135,410
1912.....	2,541	(d) 7,545	(e)3,262	1,380	5,110	(h)1,049,670	22,009	21,220	141,491
1913.....	2,081	(d) 7,607	(e)5,234	1,417	5,142	(h) 914,371	24,927	20,550	68,752
1914.....	2,610	(d) 4,634	(e)5,127	1,644	5,823	(h) 969,926	25,119	20,356	57,963
1915.....	3,407	( )10,599	(e)5,779	1,593	13,714	(h) 990,857	20,568	40,689	391,857
1916.....	4,431	(d)13,105	(e)8,664	2,730	15,905	(h)1,435,202	28,026	41,407	.....
1917.....	.....	.....	(e)1,439	.....	.....	(h)1,207,490	21,650	66,420	.....
1918.....	.....	.....	(e) 807	.....	.....	(h)1,115,935	22,993	19,371	.....

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Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		Zinc and Mfrs.
	Carbonate. (i)	Hydrate.	Nitrate.	Sulphate. (f)			Salts. Kg.	Block and Scrap.	
1905....	13,592	1,489	22,946	16,935	18,631	3,424	1,727	595	3,789
1906....	14,974	1,478	27,174	19,948	22,745	2,535	2,102	819	4,514
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,894	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,340	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	(k)73,045	1,032	6,975
1913....	18,473	.....	33,891	31,740	39,715	1,114	(k)56,982	1,083	6,114
1914....	18,698	.....	41,657	32,401	36,054	455	(k)55,931	1,482	7,835
1915....	21,622	.....	30,913	42,615	26,431	36	(k)54,423	4,240	9,762
1916....	14,983	.....	36,360	57,571	26,884	1	(k)29,816	998	9,993
1917....	3,829	.....	17,178	46,298	14,618	.....	.....	308	7,075
1918....	2,415	.....	6,763	36,733	.....	.....	.....	387	874

MINERAL EXPORTS OF SWEDEN (a)

(In metric tons or dollars; 1 krona = 27 cents)

Year.	Alum.	Ammonium Sulphate.	Antimony, Crude. Kg.	Asbestos, Kg. (c)	Cement.	Coal (Anthracite).	Copper.		Graphite.
							Ore.	Copper and Alloys.	
1903 ...	22	*Nil.*	3,473	15,357	21,319	509	1,555	1,813	9
1904 ...	9	219	3,810	16,339	27,509	605	749	1,355	7
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,586	23
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,595	12
1907 ...	7	*Nil.*	4,485	5,608	18,053	2,925	882	1,933	8
1908 ...	9	202	4,188	1,412	34,164	1,293	1,114	2,493	18
1909 ...	5	331	6,536	1,093	33,197	771	723	2,152	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	4,952	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	1,443	1,709	3,495	48
1914 ...	18	90	12,752	1,743	39,347	326	1,352	8,039	133
1915 ...	143	5,583	31,680	2,424	61,116	5	3,346	4,210	165
1916 ...	120	1	36,695	.....	77,717	1	2,278	4,654	8
1917 ...	.....	.....	.....	.....	4,651	.....	.....	.....	.....
1918 ...	.....	.....	.....	.....	6,236	.....	.....	.....	.....

Year.	Gypsum and Mfrs.	Iron and Steel.		Lead. (c)	Peat.	Phosphorus. Kg.	Potassium Chlorate.
		Ore.	Pig-Iron and Scrap.				
1903.....	119	2,827,428	79,694	524	3,217	300	790
1904.....	162	3,065,522	94,673	274	4,212	1,994	1,266
1905.....	156	3,316,626	120,987	514	5,157	34,388	1,499
1906.....	6	3,661,218	126,283	532	6,531	700	857
1907.....	16	3,521,717	139,466	519	6,524	(b)	1,753
1908.....	37	3,654,268	112,522	496	5,559	400	1,364
1909.....	21	3,196,453	112,793	319	9,999	1,305	1,400
1910.....	41	4,413,600	143,522	557	9,754	265	1,383
1911.....	13	5,086,898	158,328	1,181	10,371	595	1,564
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,653
1913.....	1	6,439,750	216,013	745	7,135	900	1,423
1914.....	48	4,787,314	181,784	414	8,981	19,025	1,591
1915.....	549	5,992,970	304,465	568	26,313	102,563	(l)1,312
1916.....	184	5,539,580	231,216	360	20,212	2,927	695
1917.....	.....	5,613,148	231,669	465	.....	.....	1,132
1918.....	.....	4,485,500	180,174	155	.....	.....	648

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Year.	Salt, Refined. *Kg.*	Silver Bullion. *Kg.*	Sodium Carbonate. (*i*)	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfrs. *Kg.*	Ore.	Crude and Mfrs.
1903....	*Nil.*	484	10	22	43.3	3,893	45,389	351
1904....	1,883	115	45	4	45.6	3,479	44,259	332
1905....	*Nil.*	10	29	4	33.9	654	51,765	295
1906....	8,652	77	13	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	54.0	274	38,543	908
1909....	6,422	437	27	5	42.5	256	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.1	152	41,854	2,158
1912....	1,668	2,021	3	76	109.8	698	41,985	3,136
1913....	6,916	4,300	2	239	86.6	2,640	46,696	6,533
1914....	495,839	4,456	30	80	517.4	3,985	41,499	6,333
1915....	4,062,100	8,972	456	759	3,431.0	13,526	42,157	8,327
1916....	.....	14,537	53	.....	35.6	6,490	9,351	5,788
1917....	.....	.....	.....	.....	28.9	.....	6,329	6,417
1918....	.....	.....	.....	.....	22.9	.....	16,210	826

(*a*) From *Sveriges Officiella Statistik Handel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes sodium cyanide. (*e*) Includes sodium and potassium. (*f*) Includes sodium bisulphate. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes bicarbonate. (*k*) Includes tin chloride and tin oxide. (*l*) Includes sodium chlorate.

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UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (*a*)

(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (*c*)	Coal.
1905....	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906....	9,605	1,625	650	36,319	6,760	4,825,299	12,459,213	255,067,622
1907....	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,786	(*h*)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	5,965,423	14,057,090	276,255,764
1912....	11,446	2,228	1,806	43,453	5,882	4,962,408	13,022,433	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	6,179	2,007	(*b*)	49,718	8,421	4,362,689	13,343,100	270,070,414
1915....	8,038	2,537	428	63,483	11,914	3,285,983	9,014,657	257,282,699
1916....	6,362	2,586	305	77,258	10,495	2,831,181	6,605,044	260,503,009
1917....	.....	2,668	384	66,612	14,961	.....	5,936,742	252,500,078

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland) (*c*)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1905.....	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906.....	7,882	(*b*)	42,521	17,662	(*b*)	2,404,857	228,627	5,512
1907.....	6,867	677	50,257	13,186	59.4	2,438,798	239,285	6,391
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	296	29,154	173	49.7	2,227,975	247,724	3,397
1913.....	2,108	428	54,557	4	4.9	2,449,305	242,341	3,899
1914.....	2,561	347	34,360	55	3.2	2,540,520	269,637	2,381
1915.....	835	238	33,656	5,169	39.1	2,388,106	251,209	2,018
1916.....	1,045	282	55,612	1,360	8.5	1,993,233	222,814	1,113
1917.....	1,178	190	65,918	*Nil.*	*Nil.*	1,960,224	175,800	.....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1905....	14,824,183	(*f*)9,746,221	28,091	20,977	14,582	16,468	2,536,784	*Nil.*
1906....	15,748,412	(*f*)9,999,211	30,710	22,693	23,126	14,437	2,586,851	*Nil.*
1907....	15,983,310	(*f*)9,850,953	33,053	24,853	16,356	14,927	2,732,968	33
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909....	15,220,408	(*f*)9,818,916	30,221	22,823	2,812	16,575	3,014,678	4
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	*Nil.*
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	.....
1912....	8,552,343	4,525,830	25,729	19,473	4,237	14,179	3,235,942	.....
1913....	16,263,950	5,224,607	24,656	18,462	5,480	15,387	3,333,048	.....
1914....	15,115,375	4,865,858	26,422	19,684	3,494	11,247	3,321,291	.....
1915....	14,464,196	4,640,885	21,078	15,770	4,716	9,134	3,046,930	.....
1916....	13,811,920	4,388,633	17,382	12,775	5,962	10,323	3,057,680	.....
1917....	15,084,750	(*f*)9,488,447	15,569	11,431	10,102	.....	3,167,852	.....

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Year.	Pyrite.	Salt.	Silica (Chert and Flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (*d*)	Sandstone.	Slate.
1905	12,381	1,920,149	71,808	5,212	6,052,210	12,701,808	5,729,799	523,892
1906	11,318	1,996,593	69,300	(*b*)	6,264,402	12,962,725	5,345,328	500,546
1907	10,358	2,016,409	54,523	4,780	5,765,262	12,709,288	5,092,246	450,651
1908	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
1910	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
1911	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
1912	10,691	2,157,621	75,963	3,955	6,748,852	11,692,338	3,903,560	389,812
1913	11,611	2,285,221	76,105	4,439	7,216,801	12,953,008	4,043,591	376,935
1914	11,848	2,103,316	77,483	4,555	7,250,120	12,361,082	3,520,306	324,227
1915	10,705	2,037,895	104,351	2,930	6,183,390	11,294,875	2,561,442	229,676
1916	10,650	1,992,011	51,407	2,690	4,921,151	10,711,292	2,031,497	179,674
1917	8,652	.....	.....	.....	4,307,669	10,623,038	1,639,354	123,480

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore, Dressed.	Block.			Ore.	Spelter.
1905	14,523	7,316	4,540	174	105	24,025	9,023
1906	14,338	6,376	(*b*)	267	11	23,189	(*b*)
1907	10,917	7,192	4,478	327	72	20,402	7,222
1908	16,733	8,137	5,133	237	72	15,469	5,926
1909	14,267	8,422	5,282	382	6	10,061	5,828
1910	4,838	7,693	4,874	275	76	11,418	4,235
1911	5,963	7,870	4,950	270	68	17,935	6,196
1912	19,693	8,302	5,342	192	43	17,988	60,163
1913	18,732	8,494	5,376	185	96	18,073	5,920
1914	13,376	8,220	5,144	208	350	15,676	5,295
1915	650	8,275	5,048	334	83	12,254	4,162
1916	2,553	8,019	4,773	400	52	8,612	3,048
1917	2,618	6,682	3,998	245	13	7,604	.....

(*a*) From *Mineral Statistics of the United Kingdom*. (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*h*) Includes shale.

MINERAL IMPORTS OF THE UNITED KINGDOM (*a*)

(In metric tons or dollars; £1 = $5)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke, and Pat. Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1906	(*c*)14,070	(*b*)	16,955	49,269	97,789	76,073	75,487	7,634,839	90,674	36,559
1907	(*c*)15,579	(*b*)	17,551	19,136	105,409	73,101	89,312	7,764,589	104,950	27,404
1908	(*c*)13,732	(*b*)	(*n*)19,424	3,904	111,897	71,120	124,226	6,154,733	69,930	24,653
1909	(*c*)10,857	(*b*)	(*n*)16,349	6,419	(*l*)90,579	(*l*)66,337	(*l*)133,758	(*l*)6,429,996	(*l*)111,300	(*l*)33,475
1910(*i*)	(*c*) 8,996	(*o*)14,415	16,277	36,615	99,755	70,081	89,279	7,133,483	173,680	70,176
1911	(*c*) 9,463	(*o*)20,866	20,621	30,672	87,986	65,914	101,059	6,448,462	178,167	51,002
1912	8,812	(*b*)	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,195
1913	9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,854
1914	10,583	.....	20,493	45,315	72,766	43,252	152,974	5,799,918	227,099	112,405
1915	8,757	.....	21,672	3,843	38,766	39,011	183,393	6,306,547	202,500	115,150
1916	7,789	.....	18,850	3,257	35,047	44,545	113,206	7,017,122	162,111	99,432
1917	6,327	.....	14,206	4,382	.....	28,696	145,077	.....	.....	.....

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Year.	Iron and Steel (*Continued*). Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated. (*h*)	Lead. Ore.	Pig and Sheet.
1905..	110,576	69,831	34,439	60,318	55,331	613,612	148,995	$8,783,895	(*i*) 27,649	233,214
1906..	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	211,577
1907..	83,145	57,280	19,33	56,110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	207,970
1908..	85,270	56,652	31,393	109,313	54,251	437,238	231,859	3,034,895	23,861	241,320
1909 (*i*)	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*) 210,982
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	222,450
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	217,134
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	208,671
1913 .	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	207,559
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	.....	227,931
1915..	46,775	31,016	15,956	199,558	65,410	453,617	108,939	8,678,975	.....	260,751
1916..	44,922	40,861	5,198	140,257	80,469	166,746	96,306	6,833,717	.....	160,529
1917..	28,776	18,807	222	86,669	7,624	66,335	66,329	.....	.....	149,493

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1905.....	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	709,926
1906.....	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	771,473
1907.....	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	781,486
1908.....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	771,091
1909 (*i*)....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*) 803,725
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	825,284
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	863,583
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	921,717
1913.....	611,227	(*b*)	(*b*)	57,974 (*g*)	488,106,963	548,000	(*b*)	12,092	794,740
1914.....	487,426	.....	.....	53,576 (*g*)	646,894,523	564,865	.....	10,666	816,449
1915.....	383,613	.....	.....	93,677 (*g*)	588,469,699	380,883	.....	14,060	918,468
1916.....	446,585	.....	.....	75,217 (*g*)	451,931,774	338,738	.....	22,317	966,520
1917.....	..	.....	.....	73,811 (*g*)	826,834,812	281,070	.....	.....	.....

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin. Ore.	Tin. Block, Ingot, Bars or Slabs.	Zinc. Ore.	Zinc. Spelter.	Zinc. Mnfrs.
1905.....	1,158	$10,426,570	106,107	18,163	(*b*)	40,391	23,909	92,261	20,013
1906.....	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*) 22,824	95,203	19,164
1907.....	1,341	11,224,650	115,716	15,730	21,205	44,505	(*i*) 66,076	90,756	20,663
1908.....	1,483	10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,548	38,717
1909 (*i*).....	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,217	19,280
1910.....	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,061	18,460
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,077	19,417
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,461	20,673
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,421	19,081
1914.....	1,283	4,324,576	174,775	22,162	32,938	41,644	.....	117,660	12,690
1915.....	1,381	3,446,435	134,360	36,247	45,494	39,544	.....	75,762	8,170
1916.....	1,159	3,429,646	21,232	37,281	34,458	34,188	.....	54,183	3,729
1917.....	985	.....	1,707	597,299	.....	27,580	.....	77,330	4,171

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Prior to 1900, many manufactures were not reported separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Jour.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings amounting to 51,000 tons.

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MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (*a*)
(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (*c*)
1905	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
1906	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
1907	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
1908	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(*n*) 7,711,360
1909	(*n*) 46,321	607,825	64,089,132	(*l*) 1,180,218	(*l*) 1,479,142	20,029,427	(*n*) 7,276,050
1910(*k*)	(*n*) 51,188	747,627	(*l*) 63,081,948	979,526	1,494,397	(*l*) 19,839,123	(*n*) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
1912	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
1914	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	£2,283,062
1915	25,086	432,243	44,260,356	1,027,140	1,245,489	13,858,147	£2,554,008
1916	8,794	416,602	38,969,013	1,505,350	1,346,023	13,197,282	£3,212,046
1917	2,650	363,441	(*r*) 38,409,296	(*s*)	(*s*)	(*s*)	(*s*)

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
1905	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
1906	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
1907	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
1908	14,869	15,546	19,796	(*m*) 72,429	4,478	1,317,330	135,115	48,336	174,539
1909(*k*)	12,465	(*m*) 11,381	17,248	(*m*) 45,547	(*l*) 5,185	(*l*) 1,026,517	(*l*) 165,183	(*l*) 44,406	(*l*) 171,697
1910	11,898	(*m*) 15,970	12,551	43,391	(*l*) 7,464	(*l*) 1,062,444	(*l*) 150,507	(*l*) 57,148	(*q*) 143,702
1911	10,970	15,101	24,669	81,112	(*l*) 6,352	1,222,622	147,759	(*l*) 70,618	140,318
1912	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
1914	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	151,062
1915	6,764	3,923	14,076	66,297	1,697	621,810	52,031	47,647	121,826
1916	9,339	1,654	8,114	39,437	1,263	932,186	62,596	36,895	140,158
1917	5,262	497	3,611	47,888	678	745,590	17,026	23,288	10,897

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
1905	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
1906	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
1907	595,272	103,100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
1908	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
1909(*k*)	(*l*) 589,499	(*l*) 107,406	(*l*) 169,918	(*l*) 502,791	(*l*) 61,025	(*l*) 446,781	(*l*) 3,217	(*l*) 309,555	4,278,172
1910	490,068	(*l*) 124,703	(*l*) 197,858	(*l*) 606,530	(*l*) 56,691	(*l*) 490,733	(*l*) 3,340	(*q*) 230,850	4,661,647
1911	381,320	(*l*) 129,252	(*l*) 203,850	627,215	(*l*) 68,137	492,104	(*f*) 4,376	231,793	4,588,385
1912	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
1914	451,030	100,938	145,017	576,044	58,192	442,755	5,784	328,061	3,946,688
1915	257,552	64,407	250,400	291,187	54,383	374,742	16,106	555,115	3,248,454
1916	55,263	53,281	340,741	119,097	139,138	326,890	84,186	642,469	3,349,294
1917	39,813	49,791	229,045	19,225	13,685	180,071	168,210	77,596	2,366,330

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Year.	Lead, Pig and Mfrs.	Salt.	Sodium.				Tin, Block.	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfrs.
1905 ..	42,265	588,389	67,678	28,425	68,675	33,681	7,741	(b)	7,451	(i)
1906 ..	45,612	629,658	86,232	26,970	72,218	44,448	8,631	(b)	7,962	(i)
1907 ..	44,068	592,989	91,120	29,539	70,432	45,898	8,808	11,511	6,666	(i)
1908 ..	50,221	532,101	(n) 83,713	(n) 20,805	(n) 73,769	(n) 22,974	9,486	3,833	8,537	(i)
1909(k)	(m) 46,399	523,690	(n) 97,480	(n) 23,378	(n) 80,439	(n) 35,587	11,373	(b)	(m) 8,684	(i)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(b)	9,247	(i)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(b)	9,736	(i)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(b)	10,881	.....
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	....	11,313	.....
1914 ..	36,486	504,848	181,754	37,724	75,618	40,366	13,599	.....	7,580	.....
1915 ..	40,835	508,022	221,850	43,517	56,781	31,931	14,389	.....	2,428	.....
1916 ..	28,883	396,518	159,770	45,268	29,670	24,760	18,315	.....	3,621	.....
1917 ..	9,466	313,603	145,653	22,682	.....	18,815	19,597	.....	7,939	.....

(a) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (b) Not reported. (c) Including naphtha, paraffin, paraffin oil and petroleum. (d) Previous reports not available. (e) Includes puddled iron. (f) Includes railroad material of all kinds. (g) Includes all soda compounds; not sep rate; enumerated previous to 1901. (h) Included under soda ash. (i) Included under spelter. (k) From *Mines and Quarries.* (l) From *Iron and Coal Trades Review.* (m) *Mining Journal.* (n) From *Oil, Paint and Drug Reporter.* (q) Bars only. (r) Includes coke, etc. (s) Included with coal.

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UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty-free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, and special acknowledgment is due to the Chief of this Bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS (a)

Year.	Aluminium. Crude. Lb.	Kg.	Value.	Value per Lb.	Ammonium Sulphate. Lb.	Metric Tons.	Value.	Value per Lb.
1909	5,109,843	2,317,784	$745,963	$0.145	85,829,334	38,932	$2,114,694	$0.024
1910	(o)12,271,277	5,567,730	1,844,830	0.151	184,686,534	83,795	4,668,820	0.025
1911	4,173,308	1,893,000	598,272	0.143	189,265,797	85,850	5,066,470	0.027
1912	22,759,937	10,326,650	3,032,889	0.136	119,085,120	54,049	3,447,225	0.029
1913	23,185,775	10,519,861	3,905,977	0.169	130,549,440	59,252	3,957,307	0.030
1914	16,241,340	7,369,029	2,729,383	0.168	166,031,040	75,356	4,475,603	0.027
1915	8,534,834	3,871,375	1,511,988	0.165	72,748,480	33,008	1,934,625	0.027
1916	6,646,385	3,014,734	1,729,298	0.260	29,034,880	13,171	954,815	0.033
1917	58,703	26,627	18,084	0.308	16,269,120	7,380	649,125	0.041
1918	1,800,436	816,660	569,150	0.316	6,704,320	3,041	425,881	0.063

Year.	Antimony. (p) Lb.	Metric Tons.	Value.	Value per Lb.	Antimony Ore. (r) Lb.	Metric Tons.	Value.	Value per Lb.
1909....	9,652,568	4,335	$619,179	$0.064	3,386,708	1,575	$94,249	$0.027
1910....	9,899,514	4,487	572,031	0.058	*Nil.*	.....	.....	.....
1911....	10,957,844	4,970	573,564	0.052	*Nil.*	.....	.....	.....
1912....	17,645,870	8,006	936,920	0.053	*Nil.*	.....	.....	.....
1913....	15,333,492	6,957	878,773	0.057	49,803	221	1,739	0.035
1914....	13,070,381	5,930	737,233	0.056	1,986,082	901	54,408	0.027
1915....	17,484,030	7,933	3,633,420	0.206	3,374,012	1,531	351,540	0.104
1916....	19,749,830	8,958	5,219,885	0.264	9,485,423	4,303	1,049,806	0.111
1917...	35,649,113	16,171	4,297,680	0.121	11,920,443	5,406	1,031,998	0.087
1918....	27,748,318	12,586	2,664,263	0.096	2,719,062	1,233	176,138	0.065

Year.	Asbestos. Crude, Value.	Mfd., Value.	Total Value.	Asphaltum. Long Tons.	Metric Tons.	Value.	Value per L. T.
1909 ...	$993,254	$240,381	$1,233,635	132,807	134,939	$646,655	$4.87
1910 ...	1,235,170	308,078	1,543,248	166,379	169,041	776,283	4.66
1911 ...	1,413,541	161,442	1,574,983	174,234	177,030	778,185	4.47
1912 ...	1,456,012	363,759	1,819,771	194,775	198,021	919,467	4.72
1913 ...	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71
1914 ..	1,407,758	368,344	1,776,102	124,214	126,284	682,748	5.50
1915. ..	1,981,483	137,320	2,118,803	123,436	125,452	680,357	5.51
1916 ...	3,303,470	135,064	3,438,534	131,611	134,035	735,102	5.57
1917 ...	4,521,172	65,096	4,586,268	167,809	170,510	993,668	5.92
1918 ...	6,337,585	27,476	6,365,061	102,428	104,077	627,495	6.13

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Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909...	8,071,644	3,661	$303,728	$0.038	n)13,091	13,301	$54,707	$4.19	18,989	18,789	$83,956	$4.49
1910...	10,277,474	4,661	314,306	0.031	n)16,960	17,226	48,457	2.86	14,038	14,258	65,743	4.68
1911...	9,246,263	4,194	276,574	0.030	20,860	21,195	58,726	2.82	43,222	43,916	164,301	3.80
1912...	12,964,946	5,881	447,431	0.035	26,665	27,093	79,315	2.97	26,214	26,635	95,431	3.64
1813...	9,726,216	4,412	419,134	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99
1914...	7,267,372	3,297	274,387	0.038	25,598	26,025	77,265	3.02	24,844	25,258	96,500	3.88
1915...	6,373,624	2,891	268,194	0.042	3,404	3,460	15,613	4.59	3,421	3,477	17,500	5.12
1916...	4,322,321	1,961	232,720	0.054	146	148	2,317	15.87	30	30	87	2.90
1917...	7,909,045	3,584	674,875	0.085	84	84	85	21.50	7,691	7,815	28,989	3.77
1918...	14,996,140	6,802	1,439,223	0.096	*Nil.*	*Nil.*	*Nil.*	.....	3,653	3,712	14,791	4.05

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1909 .	183,413	83,195	$286,516	$1.56	39,820	40,459	$460,758	$11.57	4,709	4,785	$19,438	$4.13
1910 .	198,174	89,916	332,674	1.67	38,579	39,196	415,768	10.77	8,196	8,327	42,234	5.14
1911 .	172,093	78,061	311,771	1.81	37,529	38,131	407,958	10.87	2,463	2,502	12,550	5.10
1912 .	182,839	82,935	316,440	1.73	53,929	54,828	499,818	9.27	1,670	1,698	8,329	4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	627,821	9.56	921	936	5,697	6.19
1914 .	90,505	41,064	165,248	1.83	74,686	75,931	655,306	8.77	19,347	19,669	37,998	1.96
1915 .	44,362	20,122	108,288	2.44	76,455	77,704	780,061	10.20	2,998	3,047	14,922	4.98
1916 .	76,723	34,801	195,975	2.55	115,886	117,752	1,548,402	13.36	5,693	5,785	19,316	3.39
1917 .	69,250	31,411	142,300	2.05	72,063	73,223	1,098,659	15.25	11,188	11,368	46,523	4.16
1918 .	116,999	53,062	344,292	2.94	100,142	101,754	2,891,725	28.88	33,279	33,815	204,385	6.15

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T
1909....	1,257,629	1,277,814	$3,597,991	$2.56	1,262,338	$3,617,429	170,671	173,410	$735,253	$4.31
1910....	1,991,943	2,023,914	5,381,062	2.69	2,000,270	5,423,296	156,417	158,920	625,619	4.00
1911....	1,238,808	1,258,691	3,611,518	2.92	1,241,271	3,624,068	69,515	70,631	254,938	3.67
1912....	1,608,350	1,635,156	4,509,636	2.80	1,610,020	4,517,965	110,347	112,186	488,691	4.43
1913....	1,413,857	1,437,421	3,856,811	2.73	1,414,778	3,862,508	93,507	95,065	442,687	4.73
1914....	1,375,316	1,398,238	3,889,821	2.80	1,394,663	3,927,819	120,777	122,790	555,548	4.60
1915....	1,521,237	1,546,085	4,398,425	2.96	1,524,235	4,413,347	47,520	48,296	222,382	4.68
1916....	1,530,212	1,554,848	4,714,433	3.08	1,535,905	4,733,749	49,067	49,857	249,514	5.09
1917....	1,293,262	1,314,084	4,795,110	3.71	1,304,450	4,841,633	22,207	22,565	146,451	6.60
1918....	1,301,229	1,322,178	6,694,081	5.14	1,334,508	6,898,466	26,936	27,370	221,880	8.23

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1909.....	91,390,004	41,454	$743,636	$0.008	431,785	78,342	$642,397	$1.49
1910.....	101,029,345	45,839	797,260	0.008	292,314	53,053	396,428	1.36
1911.....	82,895,472	37,601	667,804	0.008	163,802	29,720	254,258	1.55
1912.....	74,235,256	33,682	597,002	0.008	65,064	11,808	93,583	1.44
1913.....	61,605,077	27,951	510,120	0.0083	77,333	14,035	134,187	1.74
1914.....	34,539,934	15,671	332,792	0.0096	115,770	20,920	193,155	1.68
1915.....	7,564,473	3,432	102,570	0.0135	40,097	7,275	57,149	1.43
1916.....	1,605,036	728	52,628	0.0328	1,714	311	4,924	2.87
1917.....	4,000	2	140	0.0350	2,207	400	6,075	2.75
1918.....	539,881	245	11,407	0.0211	287	52	1,185	4.13

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Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909.....	9,818	4,453	$11,065	$1.132	393,530	399,846	$9,113,254	$23.16
1910.....	6,124	2,778	4,806	0.785	453,747	461,007	9,182,161	20.23
1911.....	22,934	10,403	11,047	0.482	292,931	297,633	6,935,794	23.68
1912.....	31,848	14,446	15,132	0.475	499,549	507,875	12,696,532	25.42
1913.....	47,277	21,451	26,154	0.553	511,163	519,682	13,573,327	26.55
1914.....	227,886	103,397	220,593	0.97	417,222	424,176	12,172,138	29.17
1915.....	154,672	70,159	148,828	0.96	414,423	421,147	13,929,883	33.61
1916.....	206,639	93,756	192,009	0.93	631,168	641,330	29,799,581	47.21
1917.....	276,406	125,378	275,821	1.00	593,143	602,693	34,650,864	58.42
1918.....	208,596	94,617	291,699	1.40	493,675	501,623	34,334,820	69.55

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909.....	240,713,721	109,186	$30,529,425	$0.127	1,278	1,299	$18,427	$14.42
1910.....	259,210,796	117,609	31,620,689	0.122	36	.....	2,343	.....
1911.....	265,940,760	120,630	31,540,827	0.119	2,007	2,039	47,093	23.46
1912.....	305,369,592	138,552	44,259,727	0.145	2,126	2,160	48,293	22.72
1913.....	300,068,849	136,147	44,328,574	0.148	2,559	2,602	52,557	20.54
1914.....	201,549,503	91,447	27,813,866	0.138	4,613	4,690	94,424	20.47
1915.....	201,367,008	91,360	30,617,535	0.152	3,940	4,004	82,750	21.00
1916.....	287,548,126	130,429	65,384,132	0.227	3,857	3,919	165,222	42.84
1917.....	380,669,290	172,672	102,877,783	0.270	4,383	4,453	218,500	49.85
1918.....	418,588,634	189,868	99,103,163	0.235	1,950	1,981	97,500	50.00

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909....	2,696,960	1,224	$132,264	$0.049	9,836	9,993	$186,930	$19.00
1910....	1,189,664	535	53,709	0.045	16,770	16,321	344,421	20.54
1911....	712,134	323	35,384	0.050	10,232	10,396	176,890	17.29
1912....	791,667	359	32,876	0.042	15,793	16,052	284,585	18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03
1914....	761,674	346	30,017	0.039	12,662	12,873	255,554	20.10
1915....	569,639	258	22,655	0.040	8,313	8,449	180,594	21.72
1916....	217,725	99	9,286	0.043	7,511	7,632	102,459	13.64
1917....	240,764	109	14,654	0.061	650	660	8,875	13.65
1918....	623,241	284	32,499	0.052	4,956	5,036	148,228	29.91

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909...	11,406	$101,151	$30,648,147	$13,438,819	1,694,957	1,722,161	$4,579,078	$2.70
1910...	13,775	132,545	47,212,754	12,009,764	2,591,031	2,632,617	7,832,225	3.02
1911...	16,272	143,594	46,623,766	10,821,418	1,811,732	1,840,810	5,412,636	2.99
1912...	17,062	145,337	55,789,906	10,758,866	2,104,576	2,139,652	6,499,690	3.09
1913...	16,632	146,001	51,618,628	12,086,204	2,594,770	2,638,016	8,336,819	3.21
1914...	22,302	195,083	46,311,059	11,076,682	1,350,588	1,373,891	4,483,832	3.32
1915...	17,349	152,493	438,302,822	13,651,768	1,341,281	1,363,189	4,181,645	3.12
1916...	15,001	139,664	672,588,232	13,402,002	1,326,864	1,348,226	4,570,875	3.44
1917...	15,174	176,417	536,945,793	15,509,581	971,663	987,307	3,655,392	3.76
1918...	15,109	226,235	45,790,718	15,868,386	787,468	800,146	3,464,304	4.40

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Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909....	11,903	12,094	$97,277	$ 8.18	176,442	179,265	$5,112,045	$28.97
1910....	19,384	19,688	235,040	12.12	237,233	241,029	6,549,938	27.61
1911....	16,153	16,412	157,394	9.74	148,459	150,842	4,380,334	29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,481	4,770,730	36.89
1913....	26,408	26,833	206,719	7.83	156,450	159,058	6,557,095	41.91
1914....	15,178	15,431	136,526	9.00	139,683	141,218	4,694,186	33.60
1915....	5,359	5,446	50,606	9.44	89,836	91,303	4,108,180	45.73
1916....	4,612	4,686	36,389	7.89	135,349	137,528	10,239,868	75.65
1917....	92	93	1,169	12.71	76,786	78,022	7,872,105	102.51
1918....	*Nil.*	*Nil.*	*Nil.*	.....	34,711	35,270	4,968,056	143.12

Year.	Iron and Steel Scrap.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909.....	63,504	64,523	$781,426	19,210	19,518	$806,862
1910.....	72,764	73,928	928,002	38,231	38,783	1,565,999
1911.....	17,272	17,549	190,285	26,730	27,159	1,202,363
1912.....	23,612	24,006	256,710	26,112	26,547	1,151,853
1913.....	44,154	44,890	510,707	28,243	28,714	1,340,184
1914.....	34,849	35,430	277,818	15,015	16,688	625,355
1915.....	79,982	81,243	761,719	8,474	8,659	417,491
1916.....	116,039	117,907	1,140,704	7,701	7,825	647,393
1917.....	180,034	182,932	2,437,423	2,240	2,276	193,831
1918.....	63,730	64,757	1,221,752	1,469	1,493	194,597

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909...	1,542	1,567	$36,963	(§)	(§)	(§)	19,289	19,599	$2,695,630
1910...	(§)	(§)	(§)	(§)	(§)	(§)	46,578	47,323	4,075,036
1911...	(§)	(§)	(§)	(§)	(§)	(§)	29,205	29,687	2,772,614
1912...	3,780	3,843	101,544	(§)	(§)	(§)	18,702	19,014	2,941,481
1913...	10,408	10,581	216,272	(§)	(§)	(§)	26,765	27,202	3,505,463
1914...	22,571	22,947	610,037	648	659	$23,702	40,189	40,845	2,943,047
1915...	78,525	79,808	2,088,532	*Nil*	*Nil*	*Nil*	14,998	15,243	1,941,601
1916...	26,299	26,722	740,109	*Nil*	*Nil*	*Nil*	26,142	26,561	3,239,642
1917...	9,263	9,412	307,139	*Nil*	*Nil*	*Nil*	44,198	44,910	3,948,936
1918...	8,705	8,846	341,985	*Nil*	*Nil*	*Nil*	41,070	41,735	3,700,157

Year.	Sheet, Plate and Taggers, Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909...	4,711	4,787	$536,841	62,593	63,598	$3,782,952	10,544	10,613	$531,652
1910...	6,107	6,205	461,632	67,086	68,159	4,502,862	20,374	20,700	1,024,831
1911...	2,454	2,495	275,498	14,089	14,324	1,081,864	15,483	15,980	731,291
1912...	3,299	3,354	363,141	2,053	2,087	229,891	15,069	15,320	726,205
1913...	2,893	2,941	381,593	20,680	21,025	1,478,635	16,098	16,366	802,401
1914...	4,310	4,382	514,080	15,411	15,668	1,049,297	6,954	7,070	373,615
1915...	1,416	1,444	218,954	2,350	2,389	196,328	5,317	5,403	331,724
1916...	1,730	1,758	345,622	1,008	1,024	214,574	4,130	4,196	509,559
1917...	1,748	1,775	526,788	124	126	31,453	1,060	1,077	221,184
1918...	1,517	1,541	632,558	32	32	5,964	7,677	7,800	621,936

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Year.	Wire and Articles Made from.			Total Iron Imports. (a)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1909 ...	(§)	(§)	$1,117,812	$30,571,542	110,605	100,339	$4,121,380
1910 ...	(§)	(§)	1,468,741	47,115,112	105,117	106,805	4,056,722
1911 ...	(§)	(§)	1,270,426	28,995,600	87,319	79,215	3,452,695
1912 ...	(§)	(§)	1,103,192	29,328,709	83,288	75,576	3,721,583
1913 ...	(§)	(§)	1,167,368	33,601,985	57,105	51,817	2,962,139
1914 ...	(§)	(§)	1,205,456	28,642,862	28,190	25,580	1,867,064
1915 ...	(§)	(§)	640,521	20,380,093	51,086	46,358	3,431,829
1916 ...	(§)	(§)	652,889	28,131,095	29,674	26,921	2,933,022
1917 ...	(§)	(§)	348,786	25,8 2,335	72,178	65,752	8,879,980
1918 ...	(§)	(§)	273,705	24,947,077	93,367	84,701	10,891,438

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfrs.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1909.....	3,576	3,244	$230,347	40,434	18	$2,056	$33,892	$4,351,727
1910.....	3,491	3,166	202,376	(§)	.....	.....	7,073	4,259,098
1911.....	2,632	2,388	190,543	(§)	.....	.....	9,834	3,642,238
1912.....	272	247	19,917	31,284	14	2,305	7,328	3,748,828
1913.....	41	37	3,678	(§)	(§)	(§)	17,138	2,982,955
1914.....	148	134	10,082	(§)	(§)	(§)	83,672	1,960,818
1915.....	410	372	28,154	201,510	91	17,059	131,635	3,591,618
1916.....	5,655	5,773	761,537	532	.....	63	106,119	3,800,678
1917.....	5,793	5,255	649,205	12,538	6	2,699	12,966	9,542,151
1918.....	5,240	4,754	645,281	6,892	3	624	37,391	10,891,438

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1909...	694,599	315	$39,963	$0.057	90,655	32	$3,740	$0.041	760,179	345	$30,428	$0.040
1910...	686,052	311	38,919	0.057	48,693	22	2,252	0.046	822,289	373	32,750	0.039
1911...	741,071	336	46,213	0.062	24,662	11	1,196	0.048	1,163,533	528	46,170	0.040
1912...	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049
1914...	707,774	321	50,989	0.072	3:,651	15	1,805	0.054	6,014	3	260	0.044
1915...	339,157	154	24,608	0.073	20,650	9	1,422	0.069	1,968	1	132	0.067
1916...	88,617	40	8,050	0.091	1,320	1	150	0.114	20,467	9	5,302	0.259
1917...	20,238	9	1,965	0.097	*Nil.*	.....	.....	.....	50	.....	13	0.260
1918...	158	.....	131	.....	100	.....	12	0.120	5	.....	1	0.200

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1909.....	496,231	225	$27,562	$0.056	102.045	103,683	$985,019	$9.66
1910.....	600,461	269	32,199	0.053	152,078	154,511	1,542,800	10.14
1911.....	504,734	229	28,515	0.056	120,133	122,061	1,185,867	9.85
1912.....	334,551	152	20,914	0.063	123,801	125,788	1,369,665	11.06
1913.....	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92
1914.....	240 388	109	16,388	0.068	120.688	122 699	1,427,772	11 83
1915.....	171,572	78	14,061	0.082	68,159	69,272	647,241	9.41
1916.....	70,934	32	8,781	0.124	75,549	76,765	838,6 0	11.10
1917.....	33,294	15	4,892	0.147	30.574	31,066	464,706	15.20
1918.....	*Nil.*	.....	.....	.....	21,858	22,209	927,255	42.43

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Year.	Manganese Ore.				Mica. (d)	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1909.....	212,765	216,180	$1,405,329	$6.60	$493,978	$104,019	18,578	18,876	$2,927,975
1910.....	242,348	246,226	1,711,131	7.06	721,541	139,772	28,519	28,975	4,085,076
1911.....	176,852	179,690	1,186,791	6.71	469,089	104,160	23,993	24,378	3,918,556
1912.....	300,661	305,672	1,769,184	5.84	745,399	120,511	33,101	33,653	5,638,456
1913.....	345,090	350,842	2,029,680	5.87	981,601	(i)	37,623	38,250	6,427,639
1914.....	283,294	288,016	2,024,120	5.88	204,850	(i)	29,564	30,056	4,956,448
1915.....	313,985	319,040	2,633,286	8.40	244,292	19,929	45,798	46,546	7,615,999
1916.....	576,321	585,600	8,666,179	15.04	1,126,271	36,098	59,741	60,703	9,889,122
1917.....	629,972	640,118	10,262,929	15.92	1,368,020	50,011	61,053	62,036	9,612,400
1918.....	491,303	499,213	15,095,867	30.73	1,545,105	118,472	59,621	60,581	11,517,546

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfrs.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1909....	3,862,445	$198,540	$0.051	9,904	3,696	$2,557,574	$ 258.30	$410,997
1910....	24,323,829	1,438,609	0.059	10,009	3,736	3,320,699	331.77	1,717,584
1911....	69,019,304	2,406,581	0.035	2,868	1,070	1,278,293	445.71	3,587,998
1912....	309,765,930	6,033,231	0.019	3,692	1,378	1,716,630	464.96	2,777,853
1913....	731,360,523	12,997,011	0.018	4,283	1,599	1,978,770	462.01	3,065,489
1914....	724,446,909	11,500,730	0.016	2,676	999	1,154,955	431.60	1,818,668
1915....	763,705,698	10,563,628	0.014	4,644	1,733	2,077,536	447.35	334,472
1916....	890,853,850	13,887,263	0.016	3,436	1,283	2,506,531	729.49	650,788
1917....	1,324,157,815	20,604,606	0.016	2,179	813	2,095,390	961.45	319,765
1918....	1,635,597,145	25,669,795	0.016	3,819	1,426	4,144,740	1,085.29	819,240

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1909....	22,425	1,837	0.082	298,854,649	4,780,106	0.016	640,623	31,798	0.050	14,883,849	437,690	0.027
1910....	410,770	26,313	0.064	381,873,875	5,252,373	0.014	406,791	19,569	0.048	11,496,904	333,854	0.029
1911....	27,856	2,450	0.088	509,119,193	7,651,684	0.015	22,408	2,159	0.096	7,945,747	265,061	0.033
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027
1914....	27,406	2,235	0.083	371,520,195	5,745,385	0.015	31,858	2,375	0.075	2,229,856	74,743	0.034
1915....	16,001	3,666	0.229	129,346,560	2,297,149	0.018	32,942	2,902	0.088	127,270	28,095	0.022
1916..	10,199	7,189	0.705	2,598,400	348,961	0.134	459	75	0.163	11,537,033	1,519,375	0.131
1917....	1,006,740	404,783	0.402	1,366,400	158,410	0.116	2,404	962	0.400	9,217,004	667,209	0.072
1918....	709,805	248,160	0.350	848,960	102,109	0.120	20	8	0.400	9,349,305	907,279	0.097

Year	Potassium Salts, All Other. (s)		Precious Stones. (t)			Pyrite. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909.	100,180,417	$2,445,526	$9,230,287	$34,340,269	$1,267,457	692,385	703,498	$2,428,638	$3.51
1910.	116,820,873	2,777,396	9,426,647	32,424,471	1,907,148	806,590	819,495	2,773,627	3.46
1911.	155,140,643	3,909,361	9,963,393	30,224,826	1,470,167	1,001,944	1,018,025	3,788,632	3.78
1912.	131,049,932	3,185,098	9,979,582	26,218,261	989,288	964,478	980,553	3,860,738	3.88
1913.	124,519,551	3,253,245	12,630,037	27,626,937	998,723	848,674	862,819	3,611,136	4.00
1914.	.....	.....	3,008,823	13,652,861	775,364	977,372	993,662	4,706,383	4.82
1915.	41,109,008	1,461,637	7,124,316	14,161,769	387,150	974,616	990,531	4,817,977	4.95
1916.	6,578,291	449,538	11,522,198	26,420,425	307,510	1,244,519	1,264,556	6,728,318	5.41
1917.	9,373,123	1,780,883	13,573,806	20,168,954	252,730	967,340	982,914	5,981,457	6.16
1918.	9,752,991	2,717,386	13,210,076	8,729,904	185,939	498,786	506,816	2,767,448	5.55

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Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909..	158,487	143,777	$447,983	$2.83	$15,728,756	$30,458,946	428,429	435,569	$13,608,195	$31.43
1910..	142,549	129,320	388,015	2.72	15,913,668	29,964,500	529,172	605,938	16,601,328	31.37
1911..	137,759	124,974	378,083	2.74	16,351,154	27,395,417	544,878	553,623	16,814,256	30.86
1912..	136,391	123,762	361,664	2.65	24,053,983	24,347,103	486,352	494,458	16,554,104	34.04
1913..	150,602	136,609	416,375	2.77	19,979,971	15,887,848	625,862	636,293	21,630,811	34.56
1914..	130,752	118,649	385,752	2.95	18,941,980	7,017,207	541,715	552,777	15,228,671	28.01
1915..	123,576	112,138	366,475	2.97	26,375,801	8,108,163	772,190	784,803	22,959,997	29.73
1916..	121,967	110,648	342,588	2.81	13,615,185	18,648,104	1,218,423	1,238,041	38,131,962	31.29
1917..	65,840	59,730	280,135	4.25	15,671,915	37,668,562	1,543,213	1,568,059	60,437,526	39.16
1918..	40,315	36,574	284,032	7.05	28,148,065	44,773,517	1,845,192	1,874,900	90,379,285	48.98

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1909..	942,982	$29,771	$0.032	153,928	$3,543	$0.023	13,805,869	$350,396
1910..	2,973,522	70,901	0.027	314,396	4,269	0.014	35,895,668	406,643
1911..	990,562	34,281	0.035	3,214,129	36,252	0.011	22,202,439	303,934
1912..	884,204	29,461	0.033	3,393,354	39,912	0.012	7,332,392	232,808
1913..	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162
1914..	535,883	21,607	0.040	3,130,366	51,869	0.017	.....	.....
1915..	244,806	15,058	0.062	838,609	13,369	0.016	.....	.....
1916..	154,223	24,606	0.160	1,015,010	29,134	0.029	3,557,120	564,473
1917..	146,236	17,773	0.122	2,063,571	70,080	0.034	12,807,367	1,431,919
1918..	2,002	193	0.096	1,445	29	0.020	4,107,012	420,754

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909..	26,914	27,346	$458,954	$17.05	770	782	$23,084	966	982	$26,021
1910..	28,647	29,105	495,988	17.31	915	930	30,180	990	1,004	25,869
1911..	24,250	24,639	436,725	18.01	3,891	3,953	83,491	986	1,002	24,906
1912..	26,885	27,333	494,778	18.40	1,310	1,331	39,126	1,665	1,692	40,933
1913..	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091
1914..	22,810	23,190	409,537	18.39	621	631	17,214	1,800	1,830	47,568
1915..	24,647	25,050	405,990	16.43	647	658	23,046	988	1,004	30,335
1916..	21,289	21,632	358,416	16.84	425	432	18,408	455	462	15,020
1917..	973	989	20,176	20.73	*Nil.*	.....	.....	*Nil.*	.....	.....
1918..	55	56	1,692	30.76	*Nil.*	.....	.....	*Nil.*	.....	.....

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1909...	8,377	7,599	$102,964	$12.29	95,350,020	43,250	$27,559,937	$0.289
1910...	8,378	7,560	106,451	12.72	105,137,740	47,703	33,921,449	0.322
1911...	7,113	6,453	88,050	12.38	106,936,872	48,506	43,390,639	0.406
1912...	10,817	9,813	121,541	11.24	116,003,385	52,633	50,371,102	0.434
1913...	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450
1914...	17,869	16,210	202,415	11.33	95,049,612	43,126	32,861,188	0.346
1915...	18,069	16,396	199,840	11.06	115,636,332	52,465	38,736,909	0.336
1916...	16,682	15,134	218,180	13.08	138,073,293	62,629	51,803,384	0.375
1917...	16,132	14,635	257,454	15.96	143,636,782	65,152	63,628,940	0.443
1918...	12,967	11,519	251,102	19.37	142,507,393	64,640	93,144,218	0.653

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Year.	Zinc. Blocks, Pigs and Old. Lb.	Metric Tons.	Value.	Value. per Lb.	Oxide. (j) Lb.	Value.	Sulphide. Lb.	Value.	Mfrs. Value
1909	19,340,029	8,772	$826,588	$0.043	6,654,352	$397,084	1,263,316	$44,873	$19,176
1910	6,904,389	3,133	289,689	0.042	6,470,097	391,670	3,726,135	99,954	27,475
1911	3,275,340	1,486	170,634	0.052	5,561,016	357,466	6,355,312	166,199	124,963
1912	22,229,831	10,086	1,280,426	0.058	5,875,057	386,153	5,904,475	153,303	293,089
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	152,980	62,256
1914	1,759,579	798	71,165	0.040	5,258,108	302,838	9,072,567	277,862	31,734
1915	1,808,964	821	131,468	0.072	1,764,887	154,149	4,251,772	144,567	15,753
1916	1,368,560	621	119,000	0.087	930,267	185,395	63,419	8,862	1,205
1917	513,153	233	25,849	0.050	248,047	53,525	9,990	6,519	515
1918	70,552	32	4,953	0.071	330,201	63,746	2,670	993	426

(a) From Summary of Foreign Commerce of the United States. (b) Includes arsenic sulphide and white arsenic. (c) Barrels of 400 lb. (d) Exclusive of ground mica. (e) Not including iron ore. (f) Not reported. (h) Includes nickel oxide, alloys in which nickel is the principal constituent, and manufactures of nickel (i) Containing more than 25 per cent. sulphur. (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includes bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" steel. (n) Crude. (o) Crude, scrap and alloys in which aluminum is chief component. (p) Matte, regulus, and metal. (r) Antimony contents of ore (s) Not kainit. (t) Exclusive of pearls.

EXPORTS OF DOMESTIC PRODUCTS (a)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs. of.	Cement. Bbl.(i)	Metric Tons.	Value.	Value per Bbl.
1909	$567,375	$322,523	1,056,922	191,764	$1,417,534	$1.34
1910	949,215	348,716	2,475,957	449,314	3,477,981	1.40
1911	1,158,603	448,395	3,135,409	568,886	4,632,215	1.48
1912	1,347,621	601,701	4,215,532(p)	726,606	6,160,341	1.46
1913	966,094	754,102	2,964,358(p)	510,949	4,270,666	1.44
1914	1,546,510	513,037	2,140,197(p)	364,414	3,088,809	1.44
1915	3,682,117	764,050	2,565,031(p)	437,466	3,361,451	1.31
1916	15,417,134	1,215,209	2,563,976(p)	437,263	3,828,231	1.49
1917	14,586,467	2,049,131	2,586,215(p)	441,078	5,329,588	2.06
1918	10,869,388	2,544,378	2,252,446(p)	384,154	5,912,166	2.62

Year	Coal. Anthracite. Long Tons.	Metric Tons.	Value.	Value per L. T.	Bituminous. Long Tons.	Metric Tons.	Value.	Value per L.T.	Coke. Long Tons.	Value.
1909	2,842,714	2,888,340	$14,141,468	$4.97	(m) 9,693,843	9,849,429	(m) $24,300,050	$2.51	895,461	$3,232,673
1910	3,021,627	3,070,124	14,785,387	4.89	(m) 10,784,239	10,957,326	(m) 26,685,405	2.47	879,073	3,053,293
1911	3,553,999	3,611,041	18,093,285	5.09	(m) 13,878,754	14,101,508	(m) 34,499,989	2.49	914,042	3,215,490
1912	3,688,789	3,750,268	19,425,263	5.27	(m) 14,459,978	14,700,978	(m) 36,817,633	2.55	814,800	3,002,742
1913	4,154,386	4,224,625	21,959,850	5.29	(m) 17,986,757	18,286,536	(m) 45,449,664	2.53	881,603	3,309,930
1914	3,830,244	3,894,081	20,211,072	5.28	(m) 13,801,850	14,031,881	(m) 34,104,903	2.47	592,487	2,233,686
1915	3,540,406	3,597,407	18,429,255	5.21	(m) 16,764,857	17,034,771	(m) 42,817,341	2.55	799,562	3,092,498
1916	4,165,652	4,232,719	22,470,147	5.39	(m) 18,977,346	19,282,881	(m) 45,828,092	2.41	1,048,790	4,202,236
1917	5,363,666	5,450,021	30,909,798	5.76	(m) 21,285,320	21,628,012	(m) 79,502,654	3.72	1,258,321	8,543,746
1918	4,435,543	4,506,955	29,215,689	6.59	(m) 19,956,009	20,277,301	(m) 78,664,856	3.94	1,506,986	11,861,408

Year.	Copper. Ore and Matte. Long Tons.	Metric Tons.	Value.	Value per L. T.	Ingots, Bars, Plates and Old. Lb.	Metric Tons.	Value.	Value per Lb.	Mfrs. Value.	Total, Except Ore.
1909	59,880	60,841	$1,335,316	$22.29	682,846,726	309,734	$89,367,455	$0.131	$3,217,185	92,584,640
1910	43,784	44,585	1,049,086	23.96	695,107,043	315,384	88,949,799	0.128	5,132,287	94,082,086
1911	57,915	58,844	2,352,080	40.61	786,553,208	356,778	98,168,182	0.122	5,159,664	103,327,346
1912	66,171	67,274	3,203,220	48.41	775,000,658	351,634	123,007,884	0.159	3,762,283	126,770,167
1913	65,684	66,779	2,973,997	45.28	926,241,092	420,255	143,353,624	0.155	1,555,493	144,909,117
1914	43,529	44,254	1,606,855	36.91	840,080,922	381,162	116,026,290	0.138	1,162,060	117,188,350
1915	57,731	58,669	453,125	7.85	681,917,955	309,311	117,250,816	0.172	7,885,472	125,136,278
1916	105,838	107,542	1,239 067	11.71	784,006,486	355,625	204,924,174	0.261	25,752,591	230,676,765
1917	67,721	68,811	1,615,960	23.86	1,126,875,368	511,139	337,107,796	0.300	16,957,876	354,065,672
1918	33,598	34,139	789,557	23.50	744,429,803	337,666	195,051,082	0.262	5,286,141	200,337,223

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Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T,
1909.....	$132,349,610	$540,211	455,934	463,251	$1,365,325	$2.99	61,989	62,994	$1,030,267	$16.66
1910.....	54,968,487	470,062	644,875	655,193	2,074,164	3.22	127,385	129,423	2,113,036	16.51
1911.....	34,488,840	499,265	768,386	780,719	2,653,448	3.45	120,799	122,738	1,874,401	15.52
1912.....	43,921,951	470,333	1,195,742	1,215,671	3,537,289	2.96	272,676	277,221	3,832,765	13.84
1913.....	88,331,790	602,781	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,306	14.50
1914.....	220,409,005	285,038	551,618	560,812	1,794,193	3.20	114,423	116,330	1,638,102	14.32
1915.....	18,902,237	419,330	707,641	719,034	2,181,629	3.08	224,509	226,891	3,667,167	16.33
1916.....	155,484,759	308,168	1,183,952	1,203,014	3,692,496	3.12	607,236	617,012	15,381,431	25.33
1917.....	371,362,421	251,463	1,132,313	1,150,543	4,464,111	3.94	656,220	666,785	24,037,051	36.63
1918.....	40,157,762	532,692	1,256,431	1,276,660	5,536,842	4.41	269,527	273,866	11,574,969	42.98

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909....	13,536	13,755	$538,436	$39.77	3,856	3,918	$200,379	104,862	106,545	$2,401,091	$22.90
1910....	18,045	18,234	726,300	40.25	(n)	(n)	(n)	58,230	59,162	1,274,732	21.89
1911....	17,683	17,967	653,320	36.94	3,731	3,791	163,853	234,267	238,027	5,150,518	21.99
1912....	21,926	22,291	841,824	38.39	12,557	12,766	539,354	294,818	299,732	6,615,131	22.44
1913....	16,615	16,892	768,501	46.25	16,841	17,122	767,631	91,847	93,378	2,200,248	23.96
1914....	5,226	5,313	203,835	39.00	9,954	10,120	457,451	50,496	51,338	1,103,702	21.86
1915....	39,726	40,375	1,471,466	37.04	29,250	29,721	1,433,879	560,704	569,721	14,176,528	25.28
1916....	74,069	75,258	3,913,849	52.83	43,208	43,904	3,251,882	1,504,562	1,528,785	90,095,601	59.87
1917....	56,332	57,239	5,046,727	89.60	58,768	59,711	7,330,301	2,017,113	2,049,589	161,391,007	79.98
1918....	63,367	64,384	6,576,362	103.78	50,673	51,486	7,711,195	1,786,289	1,815,039	150,617,431	84.32

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1909	22,256,458	10,095	$456,635	$0.021	85,387,006	38,731	$1,993,142	$0.023	75,305	76,513	$4,706,592
1910	18,208,116	8,261	361,838	0.020	118,881,375	53,939	2,693,753	0.023	102,534	104,175	6,412,458
1911	25,585,379	11,605	470,515	0.018	148,875,384	67,529	3,279,105	0.022	134,497	137,113	8,353,089
1912	20,856,790	9,463	359,962	0.017	186,646,470	84,685	3,976,571	0.021	193,719	196,948	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,014,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413
1914	7,667,552	3,479	142,285	0.019	103,535,214	46,953	2,264,031	0.022	48,818	48,018	3,128,184
1915	9,487,774	4,304	190,667	0.020	255,562,644	115,923	6,048,240	0.024	101,449	103,082	6,603,002
1916	10,645,098	4,828	312,195	0.029	417,489,036	189,173	13,920,560	0.033	131,803	133,925	11,486,267
1917	10,136,192	4,598	434,766	0.043	348,214,785	157,947	17,965,560	0.051	148,723	151,097	20,748,607
1918	8,566,841	3,886	440,311	0.051	225,090,434	102,099	14,492,776	0.064	109,497	111,255	18,924,748

Year.	Steel, Sheets and Plates.			Iron Rails.				Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909..	104,742	106,423	$4,627,614	*Nil.*	.....	.....	.....	299,540	304,533	$8,519,793	$28.44
1910..	171,982	174,734	7,514,832	*Nil.*	.....	.....	.....	353,180	358,831	10,162,522	28.77
1911..	237,428	241,239	9,800,215	*Nil.*	.....	.....	.....	420,874	427,629	12,229,045	29.05
1912..	352,802	358,682	14,508,622	*Nil.*	.....	.....	.....	446,473	453,914	13,053,774	29.24
1913..	364,448	370,522	14,472,711	*Nil.*	.....	.....	.....	460,553	468,229	13,979,549	30.35
1914..	232,078	235,946	9,308,312	*Nil.*	.....	.....	.....	174,680	177,591	5,103,918	29.22
1915..	318,154	323,276	11,764,484	*Nil.*	.....	.....	.....	391,379	397,680	12,095,170	30.90
1916..	383,755	389,933	23,046,571	*Nil.*	.....	.....	.....	540,828	549,535	20,417,582	37.76
1917..	683,015	693,980	84,543,248	*Nil.*	.....	.....	.....	512,669	520,923	24,023,090	39.94
1918..	715,380	726,864	90,325,952	*Nil.*	.....	.....	.....	453,944	461,253	26,440,780	58.25

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Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1909 .	90,830	92,288	$4,488,197	$49.42	149,341	151,738	$7,836,564	$52.49	20,142	20,465	$635,409	31.56
1910 .	146,721	149,069	7,127,673	48.58	171,928	174,679	9,198,005	53.49	22,869	23,235	714,553	31.25
1911 .	223,493	227,080	10,270,977	45.96	229,762	233,452	11,637,596	50.65	22,641	23,003	659,066	29.10
1912 .	288,164	292,967	12,694,804	44.05	244,711	248,790	11,536,442	47.14	64,978	66,061	1,898,986	29.22
1913 .	403,264	409,985	17,790,744	44.12	190,284	193,455	9,237,541	48.55	61,637	62,664	1,815,922	29.46
1914 .	182,395	185,435	6,961,636	38.17	180,842	183,856	8,568,589	47.38	61,856	62,887	1,810,389	29.27
1915 .	232,139	235,876	8,960,411	38.46	473,583	481,208	25,833,607	54.55	165,014	167,670	4,713,109	39.14
1916 .	300,594	305,434	17,541,862	58.48	683,025	694,028	52,224,940	76.46	158,284	160,832	8,109,111	51.23
1917 .	294,150	298,886	24,437,289	82.62	394,940	401,280	42,317,008	107.25	181,939	184,860	15,356,275	84.40
1918 .	232,714	236,461	21,466,427	92.24	392,301	398,599	44,197,043	112.66	148,522	150,906	12,469,715	83.96

Year.	Lead and Mfrs. of.	Nickel. (e)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1909...	$509,542	$4,101,976	186,305	$6,568	$0.035	68,759	$5,800	$0.084	1,046,401	$67,814	$0.065
1910...	614,158	4,704,088	180,111	5,404	0.029	100,695	8,407	0.083	940,247	55,642	0.059
1911...	680,419	8,283,777	201,843	6,165	0.030	137,295	11,483	0.084	1,112,295	61,055	0.055
1912...	651,459	8,515,332	188,711	6,770	0.036	186,000	20,459	0.110	1,026,138	62,084	0.061
1913...	738,135	9,686,794	194,570	8,448	0.043	188,043	28,092	0.149	1,119,441	72,042	0.064
1914...	5,519,908	9,455,528	124,736	4,959	0.040	209,693	25,288	0.121	1,010,449	64,113	0.063
1915...	11,758,979	10,128,514	158,263	4.283	0.027	281,609	33,885	0.120	836,959	49,989	0.059
1916...	17,095,451	12,952,493	172,028	7,030	0.041	355,870	68,661	0.192	854,688	55,863	0.065
1917...	18,243,661	8,936,620	172,121	7,668	0.045	415,879	93,134	0.224	658,156	48,954	0.074
1918...	15,330,910	6,927,041	205,829	12,084	0.059	559,125	139,593	0.250	491,110	50,354	0.102

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Fuel and Gas Oil. (g)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1909 ...	161,640	$20,076	$0.124	107,999	$3,640	$0.034	181,328	82.6	$7,609	$0.042
1910 ...	163,832	20,291	0.125	117,605	3,732	0.032	199,913	90.7	7,329	0.037
1911 ...	183,320	23,337	0.127	133,979	3,882	0.029	214,018	97.1	7,048	0.033
1912 ...	216,393	28,297	0.131	266,237	6,599	0.025	294,591	133.7	9,603	0.033
1913 ...	207,639	29,609	0.143	426,872	11,126	0.026	236,046	107.1	8,177	0.035
1914 ...	191,648	26,316	0.137	703,508	19,224	0.027	188,823	85.7	6,435	0.034
1915 ...	239,679	32,460	0.135	812,216	22,325	0.028	386,914	175.5	12,535	0.032
1916 ...	260,806	43,027	0.165	964,091	27,141	0.028	376,813	170.9	14,820	0.039
1917 ...	280,438	57,565	0.205	1,124,524	45,656	0.041	311,090	141.1	17,907	0.058
1918 ...	257,316	75,602	0.294	1,201,051	66,657	0.055	235,437	106.8	22,263	0.095

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (c)	In Ore (d)
1909....	1,020,556	1,036,936	$7,644,368	$7.49	510,241	231	$266,243	$56,876,292	$716,017
1910....	1,083,037	1,100,366	8,234,276	7.63	144,237	65	91,077	53,298,048	346,735
1911....	1,246,577	1,266,585	9,235,388	7.41	21,841	10	13,995	59,756,121	129,909
1912....	1,206,520	1,226,629	8,996,456	7 46	23,283	11	13,360	66,846,486	137,752
1913....	1,366,508	1,389,283	9,996,580	7.32	85,521	39	43,574	59,509,520	154,769
1914 ...	964,114	980,183	6,771,652	7.02	108,426	49	70,753	47,767,578	76,084
1915....	253,421	257,501	1,603,851	6 33	252,852	115	225,509	47,403,607	63,628
1916....	243,678	247,601	1,156,391	4.74	666,047	302	670,475	70,550,279	44,758
1917....	170,202	172,942	941,823	7.87	808,336	367	998,470	83,963,550	167,336
1918....	150,932	153,362	1,191,865	7.90	232,364	105	338,680	239,940,918	18,248

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Year.	Zinc Ore.				Zinc, Pigs, Bars, Plates and Sheet.			
	Long. Tons.	Metric Tons.	Value.	Value Per L.T.	Lb.	Metric Tons.	Value.	Value. per Lb.
1909	11,121	11,299	$412,300	$37.01	5,131,360	2,328	$263,010	$0.051
1910	17,599	17,881	649,425	36.90	7,979,457	3,620	426,500	0.053
1911	16,322	16,584	642,884	39.39	13,744,212	6,234	810,099	0.059
1912	20,847	21,194	823,997	39.53	13,268,186	6,020	864,292	0.065
1913	15,815	16,079	631,991	40.00	15,565,324	7,062	955,667	0.061
1914	9,920	10,085	388,464	39.06	129,694,022	58,804	8,540,668	0.066
1915	743	755	35,276	47.48	251,348,910	114,008	31,556,838	0.125
1916	70	71	3,992	57.03	412,726,882	187,213	59,391,085	0.144
1917	1,179	1,198	63,043	53.47	436,947,774	198,195	50,765,389	0.118
1918	55	56	2,480	45.09	200,197,310	90,807	20,558,827	0.103

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1909	26,691,347	13,468	$1,026,377	$0.035
1910	26,333,993	11,949	943,968	0.036
1911	29,236,779	13,262	1,051,311	0.036
1912	34,128,163	15 484	1,247,702	0.037
1913	28,932,953	13,127	1,136,257	0.039
1914	31,183,369	14,148	1,408,525	0.045
1915	39,978,569	18,134	2,068,428	0.052
1916	27,883,602	12,648	2,394,709	0.086
1917	30,891,886	14,012	3,148,898	0.102
1918	24,841,747	11,268	2,779,507	0.112

RE-EXPORTS OF FOREIGN PRODUCTS (*a*)

Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909	6,648	3.0	$475	0.25	0.23	$ 56	6,867	6,977	$48,375
1910	339,685	154.1	20,392	*Nil.*	*Nil.*	*Nil.*	5,830	5,948	29,942
1911	160,844	73.0	9,737	*Nil.*	*Nil.*	*Nil.*	3,402	3,457	48,552
1912	(*o*)50,684	23.0	2,766	*Nil.*	*Nil.*	*Nil.*	2,589	2,632	62,276
1913	63,620	29.0	4,365	0.18	0.16	22	1,282	1,303	25,954
1914	1,600,979	725.7	211,742	*Nil.*	*Nil.*	*Nil.*	21	21	387
1915	3,146,135	1,427.0	786,766	.....	.....	8	237	241	4,706
1916	3,018,251	1,369.0	761,045	231	209	9,874	97	99	1,568
1917	989,477	449.0	169,260	*Nil.*	*Nil.*	*Nil.*	17	17	715
1918	1,410,970	640.0	164,666	*Nil.*	*Nil.*	*Nil.*	659	670	9,483

Year.	Cement.			Chemicals.					
				Salts of Potassium. (*f*)			Chloride of Lime.		
	Bbl. (*i*)	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1909	4,198	762	$6,312	2,332,386	1,058,251	$66,352	13,964	6,334	$292
1910	17,914	3,251	24,878	2,187,787	922,645	60,648	496	225	6
1911	8,529	1,547	14,095	2,731,792	1,239,133	67,297	17,804	8,076	241
1912	4,586(*p*)	791	8,419	4,932,143	2,237,814	103,425	400	181	8
1913	2,687(*p*)	460	4,075	8,660,837	3,929,599	162,467	13,260	6,016	333
1914	757(*p*)	130	1,038	8,760,640	3,974,882	204,423	15,990	7,255	291
1915	1,142(*p*)	197	2,209	3,005,825	1,363,433	279,660	120,126	54,489	2,496
1916	625(*p*)	108	814	825,673	374,517	107,578	*Nil.*	*Nil.*	*Nil.*
1917	*Nil.*	*Nil.*	*Nil.*	236,450	107,251	75,002	2,215	1,005	217
1918	5	1	100	2,879	1,306	1,845	480	218	18

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Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Sodium Cyanide.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value
1909.	8,233	8,365	$377,571	.....	.....	.....	.....	.....	....	1,053,410	477,816	$21,777
1910.	5,784	5,878	250,550	.....	.....	.....	.....	.....	....	333,427	151,282	11,767
1911.	6,787	6,896	269,274	.....	.....	.....	.....	.....	....	611,922	277,566	14,479
1912.	8,853	8,995	440,200	.....	.....	.....	.....	.....	....	431,407	195,685	9,416
1913.	5,560	5,653	295,111	.....	.....	.....	.....	.....	....	534,470	242,500	12,672
1914.	9,220	9,374	460,868	*Nil.*	*Nil.*	*Nil.*	.....	.....	....	.....	.....	13,662
1915.	22,743	23,109	1,123,761	1,897,727	860,790	347,079	.....	.....	....	.....	.....	40,358
1916.	53,453	54,314	3,432,273	222,916	101,112	58,625	.....	.....	....	.....	.....	193,086
1917.	69,779	70,902	5,367,281	276,801	125,654	115,067	.....	.....	....	.....	.....	25,632
1918.	54,706	55,591	5,204,413	125	57	145	.....	.....	....	.....	.....	73,402

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old, and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1909....	3,128	3,178	$8,532	434	2	$50	1,058,528	480	$135,952	16	$976
1910....	3,734	3,894	13,761	*Nil.*	441	5,600	55,857	25	6,443	34	3,192
1911....	3,718	3,778	10,296	*Nil.*	....	.....	200	0.1	52	*Nil.*	.....
1912....	982	998	6,574	*Nil.*	....	.....	1,020	0.5	132	*Nil.*	.....
1913....	1,179	1,199	6,652	*Nil.*	....	.....	557	0.3	135	1	44
1914....	21,390	21,747	118,241	*Nil.*	....	.....	3,436	1.6	534	*Nil.*	.....
1915....	1,343	1,365	8,966	*Nil.*	*Nil.*	*Nil.*	801,872	364	151,369	.....	.....
1916....	24,257	24,648	77,001	2,739	2,783	55,675	7,629	3.4	1,529	.....	.....
1917....	5,150	5,233	33,336	5,898	5,993	118,213	61	.....	6	.....	.....
1918....	1,064	1,079	8,046	*Nil.*	*Nil.*	*Nil.*	1,400,630	635	357,535	.....	.....

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1909.....	720	732	$25,936	....	....	.....	20	20	$1,500	*Nil.*	....	.....
1910.....	579	588	20,706	....	....	.....	9	9	356	*Nil.*	....	.....
1911.....	1,837	1,866	73,987	100	102	$1,373	12	12	635	*Nil.*	....	.....
1912.....	5,087	5,169	130,102	198	201	3,788	25	25	1,176	*Nil.*	....	.....
1913.....	765	778	29,257	70	71	771	68	69	6,099	49	50	$1,000
1914.....	218	222	14,105	186	189	2,136	13	13	1,007	*Nil.*	....	.....
1915.....	2,650	2,693	54,009	90	91	1,063	408	415	13,043	181	184	5,632
1916.....	961	976	63,555	244	248	4,667	24	24	2,137	19	19	503
1917.....	281	286	43,255	140	142	2,352	29	29	4,292	30	30	632
1918.....	1,443	1,466	286,165	*Nil.*	*Nil.*	*Nil.*	12	12	2,716	*Nil.*	*Nil.*	*Nil.*

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Year.	Iron and Steel. (*Continued.*)									Lead and Mfrs.
	Steel, Ingots, Blooms, Etc.			Sheets and Plates.			Tin and Terne Plates, Taggers Tin.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	
1909.....	60	61	$10,389	42	43	$2,630	14	14	$6,273	$3,139,908
1910.....	121	123	24,867	96	98	6,122	.....	.....	.....	2,511,850
1911.....	108	110	19,721	.....	.....	34,177	.....	.....	.....	4,067,574
1912.....	470	478	57,743	58	59	6,786	175	178	15,886	2,704,062
1913.....	418	425	60,191	*Nil.*	.....	.....	1	1	250	2,107,796
1914.....	443	450	41,052	2	2	143	67	68	4,240	1,539,039
1915.....	153	155	27,262	88	89	6,112	139	141	9,018	1,082,948
1916.....	161	164	86,501	1	1	938	6	6	1,084	33,224
1917.....	88	89	41,653	234	238	49,190	.....	.....	25	255,299
1918.....	603	613	60,069	.....	.....	165	*Nil.*	*Nil.*	*Nil.*	708,742

Year.	Salt.			Sulphur—Crude.			Tin in Blocks, Pig and Granulated.		
	Lb.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1908.....	2,525,945	1,146	$9,352	380	386	$8,500	244	248	$156,761
1909.....	1,617,705	734	1,700	16	16	284	441	448	294,649
1910.....	2,124,983	964	2,173	5	5	145	620	630	467,526
1911.....	449,025	204	646	*Nil.*	.....	.....	1,012	1,027	958,481
1912.....	73,551	33	105	1,015	1,032	20,314	589	598	591,729
1913.....	76,125,400	34,540	3,226	25	25	555	1,104	1,122	1,135,105
1914.....	5,196,300	2,357	14,349	309	314	7,074	802	815	647,017
1915.....	10,384,400	4,712	31,841	175	178	3,995	553	562	439,433
1916.....	14,897,300	6,757	61,525	104	106	2,187	140	142	129,006
1917.....	3,798,800	1,723	21,830	*Nil.*	*Nil.*	*Nil.*	79	80	84,070
1918.....	1,445,800	656	13,903	204	207	7,102	235	239	293,737

(*a*) From Summary of Foreign Commerce of the United States. (*c*) Total exports of coin and bullion. that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate, and all other salts of potassium. (*g*) Includes small amount of residuum, but does not include fuel oil for vessels engaged in foreign trade. (*i*) Barrel of 400 lb. (*m*) Does not include coal used for fuel on vessels for foreign trade. (*n*) Included in other manufactures. (*o*) Antimony contents of regulus, etc. (*p*) Barrel of 376 lb.

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Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins and Remarks.
Egypt	Gold...	Pound (100 piasters)..	4.9431	Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97½ piasters.
Finland	Gold...	Markka	.1930	Gold: 20 marks ($3.859), 10 marks ($1.93). Exchange rate, $0.15 = 1 markka.
France	Gold and Silver	Franc	.1930	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
German Empire	Gold...	Mark	.2382	Gold: 5, 10 and 20 marks.
Great Britain	Gold...	Pound sterling	4.8665	Gold: sovereign (pound sterling). Exchange value, $4.7525.
Greece	Gold...	Drachma	.1930	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti	Gold...	Gourde	.2500	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.183.
India (British)	Gold...	Pound sterling*	4.8665	Gold: sovereign (pound sterling). Silver: rupee (15 rupees = 1 pound sterling).
Indo-China	Silver..	Piaster.	.7812	
Italy	Gold and Silver	Lira	.1930	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan	Gold...	Yen	.4985	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen. Exchange value, $0.52.
Liberia	Gold...	Dollar	1.0000	Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico	Gold...	Peso†	.4985	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. Exchange value, $0.53.
Netherlands	Gold...	Guilder (Florin)	.4020	Gold: 10 florins. Silver: 2½, 1 florin, and divisions. Exchange value, $0.51.
Newfoundland	Gold...	Dollar	1.0000	Gold: 2 dollars ($2.027).
Norway	Gold...	Krone	.2680	Gold: 10 and 20 crowns. Exchange rate, $0.3175 = 1 krone.
Panama	Gold...	Balboa	1.0000	Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Gold...	Peso (Argentine)	.9648	Currency: Depreciated paper, exchange rate 3500 per cent.
Persia	Gold...	Achrefi	.0959	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans.
	Silver.	Kran	.1332	
Peru	Gold...	Libra	4.8665	Gold: ½ and 1 libra. Silver: sol and divisions. Exchange rate, about $5.46.
Philippine Islands	Gold...	Peso	.5000	Silver peso: 10, 20 and 50 centavos.
Portugal	Gold...	Escudo	1.0805	Gold: 1, 2, 5 and 10 milreis. Currency: Inconvertible paper; exchange rate, approximately, $0.705.
Roumania	Gold...	Leu	.1930	
Russia	Gold...	Ruble	.5146	Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold...	Dollar	1.0000	
Servia	Gold...	Dinar	.1930	
Siam	Gold...	Tical	.3709	
Spain	Gold and Silver	Peseta	.1930	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is notes of the bank of Spain; exchange value, about $0.275.
Straits Settlement	Gold...	Pound sterling§	4.8665	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold...	Krona	.2680	Gold: 10 and 20 crowns.
Switzerland	Gold...	Franc	.1930	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey	Gold...	Piaster	.0440	Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay	Gold...	Peso	1.0342	Gold: peso. Silver: peso and divisions.
Venezuela	Gold...	Bolivar	.1930	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

* The sovereign is the standard coin of India, but the rupee ($0.3244½) is the current coin, valued at 15 to the sovereign.

† Seventy-five centigrams fine gold.

‡ Value in Mexico, $0.4985.

§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given a tentative value of $0.5678.

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